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PROGRESS REPORT ON CITRUS HYBRIDIZATION: PROPAGATION

By JUAN P. TORRES

Of the Bureau of Plant Industry

NINE PLATES

In a previous report,(1) mention was made of the present article. The object of this paper is to portray the extent of the propagation and planting of Philippine citrus hybrids, including the methods of propagation and culture used, which may be applicable to general nursery practices.

REARING HYBRID SEEDLINGS

After the hybrid seedlings had been carefully selected, they were transferred one by one to the pricking boxes. At this stage the seedlings were from three to five months old. In the pricking boxes, they were set wide apart, from 8 to 10 centimeters, so as to maintain them for several months until the weather and nursery conditions became favorable for transplanting. For large scale propagation, pricking plots instead of pricking boxes may be used. The soil for pricking purposes was a sandy loam or loamy garden soil with an equal proportion of well-rotted compost. In the absence of sufficient organic fertilizing materials, a slight dressing of ammonium sulphate or any nitrogenous fertilizer was found to be beneficial to the seedlings. Not infrequently the seedlings under such crowded condition were attacked by citrus canker, so, as a measure of control, the seedlings were sprayed with either lime sulphur spray or Bordeaux mixture

at regular intervals of about once a week. As soon as the hybrid seedlings had reached a height of 40 to 50 centimeters they were set out in the nursery rows. Only the most vigorous ones were selected for planting in the nursery.

Nursery.—The nursery should be located either within or as near as possible the fields where the sedlings are to be transplanted. An adequate supply of water is imperative in successful nursery work. The nursery should be established on level ground with a rich clay loam soil.

In the absence of a suitable level ground, a slight slope may be used provided the nursery beds are terraced, otherwise, it will not do for the purpose. With terraced beds the nursery is not subject to severe erosion during rainy days and the water penetrates into the soil more uniformly and more easily than in unterraced beds.

On any sloping ground the soil is usually clayey and it will easily bake upon drying, forming an impermeable layer on the surface especially during the dry season. When watered, this impermeable layer prevents the penetration of water into the soil. Consequently newly planted seedlings in this kind of soil suffer wilting due to ineffective watering. To overcome such difficulty it becomes expedient to dig around each planted seedling a shallow ditch to facilitate the penetration of water into the soil surrounding the root systems of the newly planted seedlings. The terraces should be made one to one and a half meters wide and of any convenient length depending upon the grade of the ground to be worked.

The selected hybrid seedlings were thus prepared in much the same way as citrus stocks are prepared for planting in the nursery rows. The main root was cut off or pruned back to about 10 to 15 centimeters long so as to encourage a rapid development of strong lateral roots. Some of the leaves were also cut off so as to balance the volume of foliage with the remaining roots. Reduction of foliage may not be necessary if planting is done during the rainy days, but pruning insures good condition of the seedlings should any unexpected inclement weather occur. Afterwards the hybrid seedlings were set out in double or triple rows, about 40 centimeters apart. They were allowed to grow and develop in the nursery until they became large enough for transplanting into the testing fields. At times when the seedlings in the nursery rows were found quite slow in growth it was deemed necessary to apply a light dose of fertilizer, 7 to 10 grams

per plant several months before transplanting. If the application was made during the dry months, which was usually the case, the seedlings were for obvious reasons thoroughly watered just after the application of the fertilizer. Three to 4 small holes were made around each seedling to the depth of the root system and into these holes the required dose was poured. The holes were then covered. In response to the fertilizer treatment the seedlings sent out young shoots and leaves in abundance. These young shoots were allowed to develop fully and to harden before the seedlings were dug up for transplanting.

PROPAGATION

In the propagation of citrus hybrids three methods were employed: by planting the seedlings, by planting budded plants and by top–working some buds on old Batangas mandarin trees. The treatment involved in rearing hybrid seedlings for transplanting has already been discussed in the preceding paragraphs. A new method of propagation which was recently adopted so as to provide each young hybrid seedling with a double root system, is also described elsewhere in this report. This new method is a combination of inarching and tongue grafting as applied to young seedlings for both stocks and scions.(9)

PLANTING

The hybrid seedlings for planting in the trial orchards were carefully selected long before transplanting.(2) They were allowed to attain a height of not less than one meter nor more than 1.5 meters. Seedlings less than one meter high were choked out by weeds and vines and catch crops such as rice, corn, beans, yams and gabi. This will be discussed later in this report under the topic "Large versus small seedlings for planting."

The selected hybrids were balled up after pruning. This was done by removing all branches and twigs on the trunk from the ground to a height of 45 centimeters and allowing the seedlings to develop single trunks. Seedlings more than 1.5 meters high were cut to the proper height. Some of the branches, if too numerous, were removed and the long slender ones cut to suitable lengths in order to maintain a good balance between the top and the root sytem and to encourage the development of a strong well balanced crown.

It is needless to state that the best time for planting citrus is during the early part of the rainy season or any period from

May to August, when there is an abundant natural supply of moisture in the soil. However, during the dry season citrus may be planted if regular watering is possible.

The seedlings and budded plants of different crosses planted are listed in Appendix A and summarized in Table 1.

BUDDING

It was noted that the hybrids from some crosses were too weak to stand adverse conditions in the nursery. Upon closer examination they were found to have very poor root systems. Since these hybrids were too valuable to be discarded at once and were in need of utmost care, they were budded on strong stocks as soon as they had produced some normal buds, so as to give them greater chances of surviving and growing into normal hybrid seedlings. Propagation of hybrid seedlings by budding not only saves the weak hybrid seedlings but also helps in multiplying the selected hybrids for testing and further studies.

The selected normal hybrids were allowed to develop good sized branches and twigs from which scions were prepared. Some of the normal seedlings of the same cross or those of other crosses or any kind of seedlings suitable for budding were used as stocks.

Stocks.—The stems of the stocks may have attained the proper size in budding but if the bark is tight they are not in condition for the process. Failure of the stocks to take in buds would result in the stocks becoming overgrown and wasted. To keep the seedling stocks in vigorous condition and in order to gain time in the production of budded plants the less vigorous seedling stocks may be treated as those seedlings intended for direct transplanting, i. e., each seedling stock with 7 to 10 grams of any nitrogenous fertilizer. When so treated more than 90 per cent of the stocks were found to be ready for budding in four to five weeks time after the application. The method of application has already been described under the topic "Rearing Hybrid Seedlings."

Treatment of overgrown stocks.—Not infrequently many of the stocks which became overgrown were discarded and replaced with younger seedlings. Some nurserymen rejuvenated their stocks by cutting off the stem at a certain height or by lopping it off so as to induce the growth of new shoots as near to the ground as possible. These shoots were reduced to one, and budded as soon as they were in condition.(3 & 4) This process

takes at least three to six months before the stocks become suitable for the next budding operation.

When the stocks are already too large the application of fertilizer may not be advisable and to discard them would surely increase overhead expenses. A new and very practical treatment consisted of watering first the nursery so as to render the soil moist and therefore easy to cultivate. The top layer, about two inches, of the nursery was then converted into a fine tilth and the moist soil was hilled up so as to cover the stems of the seedlings to a height of about six to eight inches and then allowed to stand for sometime. After thirty to forty days all the treated stocks readily took in buds. Evidently the moist soil had softened and loosened the bark tissues rendering the stocks suitable for budding. This practical treatment to loosen the tight bark tissues of the stocks was tried successfully by the writer with no less than two thousand seedling stocks at the Economic Garden and in a private nursery.

Shield-buds.—The usual procedure in slicing the shield-buds is to hold the budstick with its distal end toward the cutter. The writer found it not only more convenient but also more reasonable to hold it in the reverse position, i. e., with its butt end toward the cutter. The claim that the wood would split when held in such a position(3) was not experienced when the knife used in cutting was very sharp. Moreover, in such a position there is a good and easy grip and unlike the usual manner of holding the stocks the buds are far from being hard-pressed by the thumb and in fact the shield-bud thus produced has a cleaner-cut upper portion. Besides, after making a perfect cut the shield-bud may be placed immediately into the incision, whereas in the usual way of holding the budstick the cut shield-bud is first handled by the other hand before it may be inserted into the incision of the stock.

Very frequently, it has been observed in budding, especially citrus, that some of the buds grow and develop into normal budded plants even though the lower portion of the shield-bud is dead provided, however, that the upper portion remains healthy and sound. On the other hand, none of them ever survive once the upper portion of the shields has turned brownish. Obviously, in cutting the buds the upper portion must be given utmost care. It is quite obvious that in the position with the butt end towards the cutter, the upper portion of the shield would have a cleaner cut and its proper length and thickness

could be easily determined since it receives the first stroke of the clean sharp edge of the knife.

Care of budded plants.—The subsequent care of budded plants as to lopping, removal of tops and other nursery routine were carried out in the usual manner. As regards proper pruning, to obtain a strong well developed crown with a single trunk and proper height for transplanting, the same methods were followed as in the case of seedlings for transplanting.

TOP-WORKING OR SHOOT-BUDDING

Apart from the meaning of top-working which is usually resorted to to eliminate undesirable trees or strains from established orchards,(5) by a gradual substitution of tops of these trees with select buds from trees of desirable strains, in this paper top-working means the budding of citrus hybrids on the side shoots or water sprouts of a large citrus tree to hasten the fruiting period of the hybrids. The idea of propagating citrus hybrids by top-working on old Batangas mandarin trees was derived from the previous experience of the writer with some citrus varieties. The writer observed at the Tanauan Citrus Sub-station and in some private orchards that top-worked buds of calamonding, King mandarin, Szinkom mandarin, Washington Navel orange and various other citrus varieties usually commenced fruiting in two to four years after budding, which is a much shorter period than obtainable from planting either the seedlings or the budded plants of the same. With seedlings and budded plants it usually takes one or two years for them to attain their proper size in the nursery and another period of from 4 to 7 years from transplanting to first fruiting. This period depends, principally, upon the variety of citrus scions used and partly upon the kind of stocks employed.

The procedure involved in top-working is to set some buds from the selected hybrid seedlings on the side shoots or water sprouts of a large tree to be top-worked. The condition of the shoots, just as in ordinary stocks must be considered because upon it greatly depends the success of the work. Top-working may be performed with excellent results while the shoots are in active growth with their lower portion assuming a whitish gray color. In this connection it is highly important to use the sprouts of healthy trees. Sprouts 50 centimeters high or a little bit less should be preferred and for obvious reasons those coming from the roots are the most preferred to bud on. Shoot-budding

with citrus hybrids was started in July, 1932 at the Tanauan Citrus Sub-station and in two other private Batangas mandarin orchards.(6) The number and kind of buds successfully grown are listed in Table 2.

LARGE VERSUS SMALL SEEDLINGS FOR TRANSPLANTING

Hybrid seedlings as well as budded hybrid plants were planted for further study and selection work in the trial orchard (Plot No. 15) of the Lipa Coffee-Citrus Station, Lipa, Batangas (Plate 1, Figs. 1 and 2). Also some of the hybrids with the parent varieties in plot No. 16 of the same station. In plot No. 15, 209 plants were planted in June and July, 1933, of which 103 were seedlings and 106 budded plants. The distancing used in plot 15, was 6 meters between rows and 3 meters between plants in the row. In plot 16 the distancing was 6 x 6 meters. Before transplanting the plants measured from 50 to 80 centimeters in height. A census taken one year after planting revealed 13 dead seedlings and 19 dead budded plants or a total of 15.5 per cent. This considerable loss of hybrids within a year after transplanting may be attributed to the small size of the plants at the time of transplanting into the field. Likewise, of the 94 budded hybrids which were also small and which were planted in May and June, 1934, in plot 16 and in the replacement hills in plot 15, 54 plants or 57.4 per cent were found dead after a year. In these two plots many of the citrus plants had been smothered by weeds and covercrops, because they were left neglected for some time for lack of labor. Evidently, the small-sized plants were very sensitive to lack of care. Better results were obtained at the Economic Garden with larger-sized plants, either budded or seedlings.

Los Baños Economic Garden trial orchards.—Two trial orchards of citrus hybrids and varieties were established in adjacent lots at the Economic Garden at Los Baños, Laguna. The first one, Experimental Citrus Orchard No. 1 (Plate 2, Fig. 1) was planted in July and August, 1933 and the second or Experimental Citrus Orchard No. 2, was established in June, 1936. In the first orchard the plants were set at distances of 6 meters quincunx; in the second orchard, at distances of 6 x 6 meters, arranged in squares.

Before planting the seedlings and budded plants were classified with respect to their individual heights into two classes. Those having a height of from 45 to 85 centimeters, averaging about 60

centimeters were classified as small-sized plants; those from 86 centimeters to about 150 centimeters, averaging about 120 centimeters large-sized. The results of observation, a year after transplanting, for three consecutive years are shown in Table 3.

In this connection it must be stated that in 1933 the plants under study had to struggle with a heavy crop of rice from the start and with corn in the latter part of the year. In 1934 there was a heavy growth of weeds including cogon, *Imperata cylindrica* Linn., aguiñgay, *Rottboellia exaltata* L. f., tapilan, *Phaseolus calcaratus* Roxb., and various other weeds. Those planted in orchard No. 2 in 1936 had a catch crop of rice at the start and then corn up to the time the census was taken. The portion of trial orchard No. 2 planted with corn was covered with a very thick growth of aguiñgay, *Rottboellia exaltata* L. f., and other grasses. Apparently due to lack of labor the plants had been subjected to somewhat adverse conditions in the field during their first-year period of establishment.

Results of transplanting large- versus small-sized plants. Los Baños Economic Garden.

Year	Size of plants	Budded or seedlings	Number planted	Number died [a]	Per cent	Average per cent
1933	large	budded	112	7	6.35	
1933	do	seedlings	88	7	7.95	7.00
1933	small	budded	102	54	52.94	
1933	do	seedlings	60	22	36.67	46.91
1934	do	budded	173	92	53.12	
1934	do	seedlings	9	5	55.56	53.29
1936	large	budded	91	4	4.4	
1936	do	seedlings	376	19	5.1	4.9

[a] The counting of the dead plants was made one year after transplanting in every case.

It can be seen from this table that the large-sized plants are better materials for transplanting in the field obviously because they can stand adverse conditions in the field better than the smaller ones.

The question of proper height of seedlings and budded plants in transplanting is important when they are likely to be subjected to the adverse effects of weeds, tall grasses, vines and catch-crops of rice, corn and the like. If cleaning and shallow cultivation around the plants could be maintained regularly so as to eliminate or minimize any adverse field conditions then the planting of small-sized citrus plants, say about 60 centimeters high, could be done without much danger. Of course, continuous

cleaning and cultivation around the plants could be easily done in small scale planting but when done on a large scale, as for instance in commercial planting such field operations would unnecessarily increase the overhead expenses. Planting large-sized plants averaging more than a meter tall but not exceeding 1.5 meters is undoubtedly very advisable in the commercial-scale planting of citrus inasmuch as the large-sized plants can stand adverse field conditions better than the small ones.

RESULTS OF PLANTING HYBRID SEEDLINGS AND BUDDED HYBRIDS

The 49 intraspecific successful crosses and 23 interspecific crosses which were planted were, for record purposes, listed in Appendix A. Also listed are the location of individual plants and the dates of transplanting. Of these 72 different crosses there are under test at present 57 crosses represented by 770 seedlings and 233 budded hybrid plants, as of August 31, 1938. The summary is shown in Table 1. In the trial orchards at Lipa there are at present 72 hybrid seedlings and 115 budded plants; in the Economic Garden at Los Baños 487 hybrid seedlings and 218 budded hybrid plants. Two hundred eleven (211) of the hybrid seedlings were distributed to coöperators for trial planting.

TABLE 1.—*Census of Philippine Citrus Hybrids as of August 31, 1938*

(Summary of Appendix A.)

Crosses	Number of hybrids planted				Number of budded plants planted		
	Lipa	E. G.	Coop.	Total	Lipa	E. G.	Total
1. China × Bat. 8865	none	11	20	31	none	none	none
2. China × King	none	11	5	16	none	none	none
3. China × Tison	none	11	9	20	none	none	none
4. King × Bat. B 87	none	11	none	11	none	8	8
5. King × Bat. 8865	11	4	none	15	17	6	23
6. King × Calamandarin	none	21	11	32	none	none	none
7. King × Dancy	none	10	27	37	none	none	none
8. King × Kishiu	none	30	30	60	none	35	35
9. King × Ladu	none	30	24	54	none	8	8
10. King × Saagkam	none	7	none	7	none	none	none
11. King × Szinkom	none	10	6	16	none	none	none
12. King × Tison	none	9	none	9	none	none	none
14. Kishiu × Lat. K4	none	10	none	10	none	4	4
15. Kishiu × Bat. K 23	none	1	none	1	none	none	none
16. Kishiu × Bat. 8865	none	9	none	9	none	12	12
17. Kishiu × China	none	2	none	2	none	9	9
18. Kishiu × Dancy	none	1	none	1	none	3	3
19. Kishiu × King	none	none	none	none	4	13	17
21. Kishiu × Szinkom	none	none	none	none	2	35	37
22. Ladu × Batangas 8865	none	19	11	30	none	none	none

TABLE 1.—*Census of Philippine Citrus Hybrids as of August 31, 1938*—Ctd.

Crosses	Number of hybrids planted				Number of budded plants planted		
	Lipa	E. G.	Coop.	Total	Lipa	E. G.	Total
23. Ladu × King	none	11	10	21	none	none	none
24. Ladu × Kishiu	none	30	20	50	none	none	none
25. Ladu × Szinkom	none	10	none	10	none	none	none
27. Szinkom × Bat. K4	none	none	13	13	none	none	none
28. Szinkom × Batangas K 23	none	10	none	10	none	none	none
29. Szinkom × Batangas 8865	15	16	none	31	34	29	63
30. Szinkom × China	none	11	10	21	none	none	none
31. Szinkom × King	6	4	none	10	6	7	13
32. Szinkom × Kishiu	none	1	none	1	none	none	none
33. Szinkom × Ladu	none	18	none	18	none	none	none
34. Szinkom × Tison	5	23	none	28	10	none	10
35. Tison × Ladu	none	11	none	11	none	none	none
36. N. Ecija × Siamese 3442	2	26	4	32	none	none	none
37. Panuban × McCarthy	none	1	none	1	none	none	none
38. Pink × La Union	none	none	none	none	2	4	6
39. Pink × Marsh	none	2	none	2	2	2	4
41. Pink × Siamese 3442 p.	none	1	none	1	none	none	none
42. Pink × Siamese 3673 p.	none	1	none	1	1	6	7
44. Siamese 3442 × Marsh	none	2	none	1	none	none	none
45. Siamese × Panuban	1	none	none	1	8	3	11
46. Siamese × Pink	none	4	none	4	5	20	25
47. Siamese × Saigon	10	7	none	17	1	none	1
48. Siamese × Vermillion	13	14	none	27	7	none	7
49. Kussaie × N. Lime	none	4	none	4	none	none	none
51. Calamonding × Ladu	none	20	none	20	none	none	none
52. King × Dougat	none	6	none	6	none	none	none
53. Kussaie × Eureka	none	3	none	3	none	none	none
57. Rough lemon × Sour orange	none	6	none	6	none	none	none
58. Szinkom × Calamonding	none	9	11	20	none	none	none
59. Szinkom × Laurel orange	none	10	none	10	none	none	none
61. Villafranca × Bahia	3	4	none	7	5	none	5
62. Villafranca × Kussaie	none	none	none	none	none	8	8
63. Villafranca × N. Lime	none	1	none	1	none	none	none
64. Villafranca Nat. hybrid	none	1	none	1	none	none	none
65. Villafranca × Nueva Ecija	4	6	none	10	3	none	3
71. Siamese 3442 × Laurel	none	none	none	none	8	6	14
72. Siamese 3673 × King	2	7	none	9	none	none	none

Lipa = Lipa Coffee–Citrus Experiment Station.
E. G. = Economic Garden.
Coop = Cooperative trial planting.

Of the hybrid seedlings and budded hybrids planted in the trial orchards, a few of the Szinkom x Batangas hybrid seedlings planted in 1933 in the Tanauan Citrus Sub-station produced fruits in 1937. The fruits of these hybrid trees were found to be superior in quality to those of the Szinkom parent although in type and general appearance there was a close resemblance. One tree of the Villafranca lemon x N. Ecija pomelo cross (E G I:R11 T7) and another of the Siamese 3442 x N. Ecija

pomelo (E G I:R4 T11) gave each a fruit in 1938. The fruits, however, were lost so their quality could not be determined. Illustrations of some promising hybrids are shown in Plates 7 and 8.

RESULTS OF TOP-WORKING

From Table 2 it can be seen that as of August 31, 1938, the total number of buds on top-worked plants was 292. Fifty buds were grown in the Tanauan Citrus Sub-station; 114 buds in A. T. C. mandarin orchard and 128 buds in A. P. T. mandarin orchard. Both of these two private orchards are located in San Vicente, Sto. Tomas, Batangas. The different crosses that had been top-worked are as follows: China x Batangas, King x Batangas, Kishiu x China, Kishiu x Dancy, Kishiu x King, Kishiu x Szinkom, Ladu x Batangas, Ladu x King, Szinkom x Batangas, Szinkom x King, Pink pomelo x La Union pomelo, 3442 Siamese x Vermillion pomelo, Szinkom x Calamonding and Villafranca lemon x Kussaie lime.

TABLE 2.—*Census of Top-worked Citrus Crosses as of August 31, 1938*

Crosses	Number of buds			
	Tan. C. Station	A. T. C. orchard	A. P. T. orchard	Total
1. China × Batangas	none	none	16	16
4. King × Batangas	none	none	2	2
14. Kishiu × Batangas	none	1	none	1
17. Kishiu × China	1	5	8	14
18. Kishiu × Dancy	none	14	2	16
19. Kishiu × King	4	13	20	37
21. Kishiu × Szinkom	none	29	15	44
22. Ladu × Batangas	none	1	none	1
23. Ladu × King	none	15	7	22
29. Szinkom × Batangas	43	27	49	119
31. Szinkom × King	none	4	none	4
38. Pink × La Union p.	none	2	none	2
48. 3442 × Vermillion p.	2	none	none	2
58. Szinkom × Calamonding	none	2	8	8
62. Villafranca × Kussaie	none	3	1	4
Totals	50	114	128	292

Twelve hybrids of the Szinkom x Batangas cross and one of the Szinkom x King cross top-worked in 1932 and 1933 started fruiting in 1935 and in 1936 (see Table 3). Buds of the Kishiu x China No. 2, Kishiu x King No. 2, Kishiu x Szinkom Nos. 1, 2 and 6, and Kishiu x Dancy No. 1, top-worked in 1934 began fruiting in 1938. The 3442 Siamese x Vermillion hybrid No. 1 top-

worked in March, 1933 flowered in 1936 and fruited in 1937, after its second flowering (only one fruit produced). Evidently, these results show beyond doubt that much had been accomplished in citrus hybridization by budding some buds of the hybrids on the side shoots of old Batangas mandarin trees.

TABLE 3.—*Performance of Top-worked Citrus Hybrids*

Crosses	Hybrid number	Date budded	Station and tree number	Season fruited	Remarks
					Fruits
Szinkom × Batangas	1	8–18–32	T—A18	1938	21
Do	1	8–18–32	T—A22	1936	27
Do	2	8–19–32	T—A19	1935	84
Do	2	8–19–32	T—A20	1936	53
Do	6	8–19–32	T—A24	1935	4
Do	6	3–11–33	T—B60	1936	95
Do	6	9–28–33	T—A89	1936	10
Do	7	8–5–32	T—B29	1936	140
Do	7	9–28–33	T—W^2—B109	1937	8
Do	8	7–11–32	T—A78	1936	27
Do	8	7–11–32	T—A79	1936	4
Do	9	9–28–33	T—B32	1936	160
Do	9	9–28–33	T—W^1—B109	1938	150
Do	15	9–29–33	T—B202	1938	20
Do	15	9–29–33	T—B209	1938	16
Do	16	9–29–33	T—B238	1938	44
Do	16	9–29–33	T—B162	1936	54
Kishiu × China	2	6–19–34	T—W^1—B67	1938	25
Kishiu × King	2	6–19–34	T—W^3—B67	1938	5
S. S. P. 3442 × Vermillion	1	3–11–33	T—SS—Pom.	1937	1
Szinkom × Batangas	18	9–29–33	APT—8	1938	53
Do	18	9–29–33	APT—7	1938	16
Kishiu × Szinkom	2	4–13–34	APT—22	1938	56
Kishiu × Dancy	1	6–9–34	APT—29	1938	62
Szinkom × Batangas	4	11–16–32	ATC—37	1937	1,200
Do	4	12–8–32	ATC—71	1938	425
Do	4	12–1–32	ATC—65	1938	125
Do	5	11–16–32	ATC—39	1936	25
Do	9	11–16–32	ATC—34	1935	15
Do	10	12–8–32	ATC—57	1938	7
Do	10	12–8–32	ATC—50	1938	200
Kishiu × Szinkom	1	6–21–34	ATC—73	1938	98
Do	6	4–13–34	ATC—41	1938	31
Do	6	6–21–34	ATC—94	1938	53
Szinkom × King	6	11–16–32	ATC—43	1935	11

NOTE.—Tanauan Citrus Station; APT—a private orchard; ATC—another private orchard.

Of those top-worked in 1932 that had already fruited for three successive years, Szibat No. 2 (the "Szi" stands for the Szinkom seed parent, the "bat" for Batangas, the pollen parent variety) was found to be very promising. The Szi-bat or Szibat No. 2 is a new variety which is found to be prolific and of better growth habits than the Batangas (Plates 3, 4, 5, & 6, Fig. 1).

In this particular hybrid are combined the strong attachment of the fruits of the Szinkom, the very pleasant flavor and aroma of the Batangas, and the attractive deep or reddish orange color of the fruits when cured. The fruits are oblate in shape and of medium size. About 1,000 budded plants of Szibat No. 2 were distributed to different parts of the Islands besides more than 500 that were propagated and planted in citrus plantations in Calauang, Laguna and Bolbok, Batangas. This new variety, due to its desirable bearing habit, strong attachment and good quality of the fruit, should be used as a substitute for the poor quality Szinkom in commercial citrus plantations.

Another promising Szibat hybrid is No. 15. It was top-worked in September, 1933. It fruited for the first time in 1937. It is now loaded with fruits of better quality and larger size than those of Szibat No. 2. The leaves are also broader. Kishiu x Dancy hybrid No. 1 which was top-worked on June 9, 1934 started fruiting during the 1938–39 season. It is expected that the hybrid will be of higher productivity than the shy bearing Kishiu parent. The growth of the top-worked branch resembles that of the Kishiu. The fruit from Siaver (Siamese 3442 x Vermillion) pomelo was seedy, intermediate in size and shape with a medium-sized nipple on the stem end. The quality is better than that of the Vermillion and the color of the flesh is pink, after the flesh-like color of the Vermillion parent. Unfortunately both top-worked buds died of bark rot.

DOUBLE-ROOT SYSTEM FOR HYBRID SEEDLINGS

The new method of providing the young hybrid seedlings with double-root systems is by inarching combined with tongue grafting.(8) This method may be applied as soon as the hybrid seedlings in the seedflats have reached a height of about 30 to 50 centimeters with stems one-half or two-thirds the size of a lead pencil, i. e., long before they reach the budable stage. The object of this experiment is to determine the effects of a double-root system versus a single-root system upon the vigor and condition of the seedlings. Hybrid seedlings with poor root systems were experimented with.

Procedure.—The seedlings of both the stock and the scion were carefully pulled up from the seedflats and prepared as in ordinary inarching, i. e., by removing part of their bark 3 to 4 centimeters long and part of the woody portion underneath from the stems down to the lowest portion near the origin of the root

systems. The stock was then split downward and the scion upward. As in tongue grafting, the "tongue" of the seedling-scion was inserted into the split of the seedling-stock and then tied firmly to it with a piece of budding tape. Afterwards the combined seedlings were planted in suitable pots. As soon as they were united (it took about a month) the top of the seedling-stock was cut off just above the union, thereby leaving each hybrid seedling used as scion with a double-root system (see Plate 9).

The experiment is hardly three months old at this writing and therefore no results can be shown.

The method which is described in the foregoing paragraphs may be of some practical value in nursery work, especially with many of the polyembryonic types of citrus(7) such as the calamonding, Szinkom, Citranges, Tangeloes, Ladu, lemons and others in which the seedlings produced from seeds are mostly vegetatively propagated or are apogamous seedlings of the seed-parents.

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

This paper presents some methods used in rearing citrus hybrid seedlings as well as budded plants. The possible advantages derived from cutting the shield-buds with the butt end of the budstick toward the cutter has been explained emphasizing the importance of the upper half portion of the "shield" as compared with the lower half. Various treatments of the young as well as the overgrown seedling stocks for budding have been discussed.

Results of experiments on large- versus small-sized plants for transplanting conducted at the Los Baños Economic Garden a year after date of transplanting showed from 46.91 to 55.6 per cent dead for the small-sized and from 4.4 to 7.9 per cent dead for the large-sized seedlings. These results seem to indicate that the large-sized citrus plants, averaging about 120 centimeters in height are more suitable for commercial transplanting than the small-sized ones, averaging only about 60 centimeters. The large-sized plants obviously can stand adverse field conditions better than the small ones.

Of the 72 different successful crosses consisting of 49 intraspecific and 23 interspecific crosses, 44 intraspecific and 13 interspecific crosses have been planted in the testing orchards of the Lipa Coffee-Citrus Station, Lipa, Batangas and the Economic Garden at Los Baños, Laguna.

The period within which to expect desired results from citrus hybrids top-worked on old Batangas mandarin trees has been greatly shortened.

Inarching combined with tongue–grafting has been resorted to so as to provide some citrus hybrid seedlings with double–root systems. This new method of propagation is of practical value in the propagation of polyembryonic types of citrus such as the calamonding, Szinkom, Ladu, Citranges, Tangeloes, lemons, and other citrus varieties in which most of the seedlings grown from seeds are apogamous or vegetatively propagated from the seed parents.

LITERATURE CITED

1. De Leon, Jose. Citrus growing in the Philippines. Phil. Jour. Agr. 1 (1930) 165–194, pls. 1–16, figs. 1–19.
2. Shamel, A. D. Citrus fruit improvement. How to secure and use tree-performance records. U. S. D. A. Farmers' Bulletin No. 794 (1932) 1–26.
3. Torres, J. P. Progress report on citrus hybridization. Phil. Jour. Agr. 3 (1932) 217–229.
4. Torres, J. P. Polyembryony in citrus and study of hybrid seedlings. Phil. Jour. Agr. 7 (1936) 37–58.
5. Torres, J. P. Progress report on the effects of Nitrophoska fertilizer on old Batangas mandarin orchard. Phil. Jour. Agr. 7 (1936) 193–205.
6. Torres, J. P. Results of citrus hybridization in the Philippines. Phil. Jour. Agr. 9 (1938) 161–176.
7. Torres, J. P. Some notes on tongue-inarching of the avocado. Phil. Jour. Agr. 10 (1939) 11–19, pls. 1–8, figs. 1–2.
8. Wester, P. J. Citriculture in the Philippines. Bur. Agri. Bul. No. 27 (1913) 1–71.

APPENDIX A.—*List of Philippine citrus hybrids planted in permanent orchards as of August 31, 1938*

(See Table 1)

	Date planted
A. CITRUS NOBILIS OR MANDARIN CROSSES	
1. China × Batangas 8865:	
10 Sdg., E.G. II: R1T2 to T11	6–17–36
1 Sdg., E.G.P.B. Shed Sec. No. 33	7–17–36
20 Sdg., Coöp. C. Tamisin Sec. 1: R5 T1 to T3; R6 T1 to T7; R7 T1 to T8 and R8 T8	8–12–36
2. China × King:	
10 Sdg., E.G. II: R13 T2 to T11	6–17–36
1 Sdg., E.G.P.B. Shed Sec. No. 13	7–21–36
5 Sdg., Coöp. C. Tamisin Sec. 1 R15 T4 to T8	8–14–36
3. China × Tison:	
10 Sdg., E.G. II: R8 to T11	6–17–36
1 Sdg., E.G.P.B. Shed Sec. No. 14	7–21–36
9 Sdg., Coöp. C. Tamisin Sec. 1 R8 T1 T7	8–13–36
4. King × Batangas: B87:	
10 Sdg., E.G. II: R20 T2 to T11	6–24–36
1 Sdg., E.G.P.B. Shed Sec. No. 26	8–12–36
8 of No. 1 on Sz. E.G. I.; R27 T10 to T15	6–26–36
2 of No. 3 on Sz. E.G. I.; R2 T3 and T4	6–30–36
5. King × Batangas 8865:	
3 Sdg., E.G. I: R12 T13 T14 and T16	7–15–33
1 Sdg., E.G. I: R18 T4	7–20–33
1 of No. 12 on Bm., E.G. I: R13 T2	7–11–33
1 of No. 18 on Sz., E.G. I: R15 T3	7–20–34
1 of No. 21 on Bm., E.G. I: R12 T15	7–11–33
1 of No. 22 on Bm., E.G. I: R12 T7	7–11–33
2 of No. 23 on Bm., E.G. I: R13 T5 and T6	7–11–33
9 Sdg., L15: R4 T1; 2, 5, 6, 9, 10, 12, 13–14	6–28–33
2 Sdg., L15: R5 T7 and R11 T13	7–14–33
3 of No. 22 on Bm., L15: R10 T1, 2 and 3	6–20–33
4 of No. 23 on Bm., L15: R10 T5, 6, 7 and 8	6–20–33
2 of No. 21 on Bm., L15: R10 T15 and R11 T12	7–14–33
3 of No. 11 on Bm., L15: R11 T1, 2 and 4	6–27–33
1 of No. 12 on Bm., L15: R11 T5	6–20–33
2 of No. 23 on Bm., L16: R10 T11 and 13	6–19–33
2 of No. 2 on Bm., L16: R10 T15 and T16	6–19–33
6. King × Calamandarin:	
10 Sdg., E.G. II: R2 T2 to T11	6–13–36
10 Sdg., Border II: R12 to R21 T12	6–20–36
1 Sdg., E.G.P.B. Shed Sec. No. 30	7–17–36
11 Sdg., Coöp. C. Tamisin Sec., I R14 T1 to T8 and R15 T1 to T3	8–15–36

	Date planted
7. King × Dancy:	
9 Sdg., E.G. II: R21 T2 to T5 T7, 9 and 11	6–23–36
1 Sdg., E.G.P.B. Shed Sec. No. 24	8–12–36
27 Sdg., Coöp. C. Tamisin Sec. II R1 T11 to T15; T3 T1 to T12; R4 T1 to T10	9– 2–36
8. King × Kishiu:	
29 Sdg., E.G. II: R1 T2 to T11	6–13–36
II Border R10 to R17 and R19 T1s.	6–26–36
E.G. II: R15 T2 to T11	8–18–36
1 Sdg., E.G.P.B. Shed Sec. No. 29	7–17–36
30 Sdg., Coöp. C. Tamisin Sec. I R1 T1 to T7; R3 T1 to T7; R4 T1 to T7 and R5 T6 to T7	8–11–36
3 of No. 19 on Bm., E.G. I: R17 T5, R18 T12 and R20 T15	7– 9–37
2 of No. 29 on Bm., E.G. I: R11 T3 and T10	7– 1–36
1 of No. 29 on Bm., E.G. I: R20 T16	7– 9–37
5 of No. 29 on Bm., E.G. I: R23 T1, 3, 5, 7 and 9	7– 9–37
2 of No. 56 on Bm., E.G. I: R4 T1 and R11 T13	7– 1–36
5 of No. 56 on Bm., E.G. I: R19 T6, 9, 12, and 14; R24 T16	7– 9–37
4 of No. 56 on Bm., E.G. I: R9 T5 R25 T13 and R29 T1 and 8	7– 9–37
8 of No. 58 on Bm., E.G. I: R15, T5, 6 and 8; R16 T1, 6, 9, 14 and 15	7– 1–36
3 of No. 58 on Bm., E.G. I: R10 T1, 5 and 7	7– 9–37
2 of No. 59 on Bm., E.G. I: R22 T8 and 13	7– 9–37
9. King × Ladu:	
10 Sdg., E.G. II: R5 T2 to T11	6–16–36
10 Sdg., E.G. II: R20 T2 to T11	6–25–36
10 Sdg., II Border R1 to R3 to R11 R12	6–26–36
24 Sdg., Coöp. C. Tamisin Sec. I R18 T5 to T8; R19 T1 to T8; R20 T3 to T8 plus 6 extra	— 8–17–36
8 of No. 14 on Sz., E.G. II: R3 T7; R4 T8; R28 T2, 4, 6 and 7; R29 T12	7– 9–37
10. King × Saagkam:	
6 Sdgs., E.G. II: R19 T5, 7 to 11	6–24–36
1 Sdg., E.G.P.B. Shed Sec. No. 21	7–21–36
11. King × Szinkom:	
9 Sdgs., E.G. II: R6 T2 to 4 and T6 to 11	6–16–36
1 Sdg., E.G.P.B. Shed Sec. No. 31	7–17–36
6 Sdgs., Coöp. C. Tamisin Sec. 1 R13 T1 to T6	8–14–36
12. King × Tison:	
9 Sdgs., E.G. II: R3 T2 to 6 and T8 to 11	6–16–36
13. Kishiu × Batangas B87:	
6 Sdgs., Still in the nursery (8–31–38).	
14. Kishiu × Batangas K4:	
9 Sdgs., E.G. II: R23 T2 to 5; T7 to 11	6–24–36
1 Sdg., E.G.P.B. Shed Sec. No. 34	8–12–36
4 of No. 4 on Sz. Coöp. C. Tamisin Sec. II: R1 T1 to 14	9–21–36

	Date planted
15. Kishiu × Batangas K23:	
1 Sdg., E.G.P.B. Shed Sec. No. 35	8–12–36
16. Kishiu × Batangas 8865:	
9 Sdgs., E.G. II: R22 T2, 4 to 11	6–24–36
3 of No. 2 on Sz., E.G. I: R12 T10 to 12	5–15–34
1 of No. 3 on Sz., E.G. I: R13 T9	5–15–34
4 of No. 2 on Sz., E.G. I: R24 T10, 11, 13 and 14	6–20–36
6 of No. 3 on R1, E.G. I: R25 T2, 3, 9, 11, 12 and 16	6–20–36
R26 T17	6–20–36
1 of No. 3 on R1, E.G.P.B. Shed Sec. No. 22	7–21–36
17. Kishiu × China:	
2 Sdgs., E.G. I: R17 T9 and R18 T9	7– 1–36
2 of No. 1 on R1, E.G. I: R10 T3 and 4	5–15–34
5 of No. 1 on Sz., E.G. I: R28 T9, 10, 12, 13 and 16	6–26–36
2 of No. 3 on RL, E.G. I: R11 T5 and R12 T15	5–15–34
18. Kishiu × Dancy:	
1 Sdg., E.G. I: R22 T16	7– 1–36
3 of No. 1 on Sz., E.G. I: R12 T6, 8 and 9	5–15–34
19. Kishiu × King:	
1 of No. 1 on Cm., E.G. I: R5 T10	5– 4–34
1 of No. 3 on R1, E.G. I: R12 T2	6–15–34
3 of No. 4 on RL, E.G. I: R2 T8, T3 T10 and R4 T4	5– 4–34
4 of No. 5 on Sz., E.G. I: R15 T1 to 4	5–28–34
1 of No. 6 on Sz., E.G. I: R15 T7	5–28–34
1 of No. 6 on Sz., E.G. I: R16 T7	7– 1–36
2 of No. 6 on Sz., E.G. I: R23 T10 and T15	6–30–36
2 of No. 5 on Sz., L. 15; R4 T3 and T3	5–26–34
2 of No. 6 on Sz., L. 15; R8 T13 and R9 T15	5–26–34
20. Kishiu × Ladu:	
22 Sdgs. Still in seed flat.	
21. Kishiu × Szinkom:	
5 of No. 1 on Sz., E.G. I: R18 T2, 3, 5, 6, and 7	6–30–36
5 of No. 3 on RL; E.G. I: R26 T9, 10, 11, 14 and 15	6–26–36
3 of No. 3 on RL, E.G. I: R8 T14 and T9 T13 and T14	5–15–34
1 of No. 3 on RL, E.G. I: B Shed Sec. No. 37	8–12–36
3 of No. 5 on RL, E.G. I: R10 T10 to 12	8–12–36
3 of No. 9 on Sz., E.G. I: R15 T9, 11 and 12	5–28–34
1 of No. 7 on Sz., E.G. I: R16 T8	5–28–34
2 of No. 8 on Sz., E.G. I: R17 T2 and T4	5–28–34
7 of No. 3 on Sz., RL, Coöp. C. Tamisin III: R2 T1 to T7	9–21–36
2 of No. 6 on Sz., Coöp. C. Tamisin III: R3 T1 and T2	9–21–36
1 of No. 4 on Sz., L15; R10 T4	5–26–34
1 of No. 10 on Sz., L16 R15 T14	6–19–34
22. Ladu × Batangas 8865:	
10 Sdgs., E.G. I: R9 T2 T11	6–17–36
9 Sdgs., Border II: R1 to R9 T1s	6–26–36
1 Sdg., E.G.P.B. Shed Sec. No. 15	7–31–36
11 Sdgs., Coöp. C. Tamisin I: R9 T3 to T8 T10 T1 to T5	8–13–36

	Date planted
23. Ladu × King:	
10 Sdgs., E.G. II: R10 T2 T11	6–17–36
1 Sdg., E.G.P.B. Shed Sec. No. 20	7–21–36
10 Sdgs., Coöp. C. Tamisin I: R12 T1 to T8 and R13 T7 and T8	8–14–36
24. Ladu × Kishiu:	
10 Sdgs., Types A, E.G. II: R24 T2 T11	6–24–36
10 Sdgs., Types B, E.G. II: R14 T2 to T11	6–18–36
10 Sdgs., Types C, E.G. II: R25 T2 to T11	6–25–36
20 Sdgs., Mixed types, Coöp. C. Tamisin (7 type A. I: R16 T1 to T7)	8–15–36
(9 type B. I: R16 T8; R17 T1 to T8)	8–15–36
(4 type C. I: R18 T1 to T4)	8–15–36
25. Ladu × Szinkom:	
10 Sdgs., E.G. II: R27 T2 to T11	6–25–36
26. Saagkam × Tison:	
Only 1 plant in the nursery (8–25–38).	
27. Szinkom × Batangas K4:	
13 Sdgs., Coöp. C. Tamisin II: R2 T1 to T13	9– 2–36
28. Szinkom × Batangas K23:	
10 Sdgs., E.G. II: R18 T2 to T11	6–24–36
29. Szinkom × Batangas 8865:	
14 Sdgs., E.G. I: R5 T1, 2, 4, to 9, R6 T3 to 8	7–10–33
2 Sdgs., E.G. I: R14 T13 and 14	7–20–33
15 Sdgs., L15: R5 T14 to 15; R9 T9 and 10 and R12 T8	6–21–33
10 of No. 2 on Bm., E.G. I: R2 T2; R6 T1; R7 T5; R8 T9; R9 T16; R11 T4, 6 and 13; R13 T14 and K16 T12	6–25–37
6 of No. 2 on Bm., E.G. I: R15 T14 and 16; R13 T2 II: R4 T12 R6 T5 ad R22 T3	10–30–36
1 of No. 3 on Bm., RH. Sec. No. 2	7–18–33
2 of No. 13 on Bm., E.G. I: R4 T2 and 3	7–10–33
2 of No. 16 on Bm., E.G. I: R4 T5 and 6	7–10–33
2 of No. 28 on Bm., E.G. I: R4 T7 and 8	7–10–33
2 of No. 22 on Bm., E.G. I: R14 T1 and 4	7–20–33
3 of No. 26 on Bm., E.G. I: R14 T6, 7 and 10	7–20–33
1 of No. 28 on Bm., E.G. I: R14 T12	7–20–33
2 of No. 1 on Bm., L15: R12 T6 and 7	6–20–33
2 of No. 2 on Bm., L15: R10 T9 and 10	6–20–33
3 of No. 3 on Bm., L15: R10 T12 to 14	6–27–33
1 of No. 7 on Bm., L15: R9 T13	6–27–33
4 of No. 8 on Bm., L15: R9 T14 and 15; R12 T9 and 11	6–21–33
3 of No. 8 on Or. L15: R12 T10, 12 and 13	6–21–33
4 of No. 12 on Bm., L15: R13 T1 to T4	6–20–33
2 of No. 13 on S.D., L15: R12 T3	6–28–33
1 of No. 7 on Bm., L15: R14 T13	6–20–33
1 of No. 12 on Bm., L15: R13 T13	6–20–33
2 of No. 15 on Bm., L15: R14 T9 and 10	6–20–33
4 of No. 16 on Bm., L15: R14 T5 to T8	6–20–33
3 of No. 26 on Bm., L15: R13 T9, 10 and 12	6–20–33
2 of No. 28 on Bm., L15: R13 T6, and T8	6–20–33

	Date planted
30. Szinkom × China:	
10 Sdgs., E.G. II: R11 T2 to T11	6–17–36
1 Sdg., E.G.P.B. Shed Sec. No. 18	7–21–36
10 Sdgs., Coöp. C. Tamisin II: R1 T1 to T10	9– 2–36
31. Szinkom × King:	
3 Sdgs., E.G. I: R9 T2 to T4	7–10–33
1 Sdg., E.G.P.B. Shed Sec. No. 16	7–21–36
6 Sdgs., L15: R7 T14 and 15, R8 T14 and 15; R11 T14 and 15	6–26–33
4 of No. 7 on Sz., E.G. II: R17 T10; R19 T6; R21 T6 and R23 T6	7– 9–37
1 of No. 34 on Bm., E.G. I: R15 T10	7– 8–33
2 of No. 4 on Sz., E.G. II: R19 T3 and T4	7– 9–37
3 of No. 19 on Bm., L15: R9 T1, 3 and 4	6–20–33
3 of No. 25 on Bm., L15: R9 T6 to T8	6–20–33
32. Szinkom × Kishiu:	
1 Sdg., E.G.P.B. Shed Sec. No. 23	8–12–36
33. Szinkom × Ladu:	
10 Sdgs., E.G. II: R12 T2 to T11	6–17–36
7 Sdgs., Border II: R22 to R28 T12s	6–26–36
1 Sdg., E.G.P.B. Shed Sec. No. 17	7–21–36
34. Szinkom × Tison:	
22 Sdgs., E.G. I: R7 T1 to T9 R8 T1 to T8; R9 T6 to T9 R16 T10	7–10–33 5–28–34
1 Sdg., E.G. H. R. Sec. No. 1	7–18–34
5 Sdgs., L15: R7 T9 to 13	6–28–33
4 of No. 2 on Aegle, L15: R8 T5 to T8	6–28–33
3 of No. 9 on Bm., L15: R8 T1, 2 and 4	6–28–33
3 of No. 19 on N.E. x 3442, L15: R8 T10 to T12	6–28–33
35. Tison × Ladu:	
10 Sdgs., E.G. II: R16 T2 T11	6–24–36
1 Sdg., E.G.P.B. Shed Sec. No. 19	7–21–36
B. Citrus Maxima or Pomelo Crosses	
36. Nueva Ecija × 3442 Siamese:	
25 Sdgs., E.G. I: R4 T9 to T11; R5 T11 to T13; R6 T9 to T13; R7 T10 to 14; R8 T– to T13 and T15; R9 T10, 11, 12 and T15	7–10–33
1 Sdg., E.G. Sec. No. 3	7–18–33
2 Sdg., L15: R3 T1 and T4	6–29–33
4 Sdg., Coöp. J. Samosa, Tanauan, Batangas	7–15–33
37. Panuban × McCarthy:	
1 Sdg., E.G. I: R19 T13	7–20–33
38. Pink × La Union:	
2 of No. 2 on Pink, E.G. I: R25 T10 and 14	5–29–34
1 of No. 2 on S. O., E.G. I: R26 T16	5–29–34
1 of No. 2 on 3442 x Pink, E.G. I: R28 T11	5–29–34
2 of No. 2 on S. O., L15: R6 T1 and T9	5–26–34

	Date planted
39. Pink pomelo × Marsh grapefruit:	
2 Sdgs., E.G. I: R14 T18 and T19	7– 1–33
2 of No. 2 on 3442 x Pink, E.G. I: R28 T14 and T15	5–29–34
2 of No. 1 on S. O., L15: R14 T11 and T12	5–26–34
40. Pink pomelo × Panuban grapefruit:	
All six seedlings produced were weak and discarded.	
41. Pink pomelo × 3442 Siamese pomelo:	
1 Sdg., E.G. Ext. R4 T11	5–30–34
42. Pink pomelo × 3673 Siamese pomelo:	
1 Sdg., E.G. I: R29 T3	5–29–34
1 of No. 1 on S. O., E.G. I: R27 T9	5–29–34
1 of No. 1 on S. O., L15: R15 T4	5–26–34
1 of No. 2 on 3442 × Pink, L15: R15 T7	5–26–34
2 of No. 2 on 3442 × Pink, E.G. Ext. R1 T10 and T14	5–30–34
1 of No. 4 on Pink × 3673, E.G. Ext. R1 T16	5–30–34
43. 3442 Siamese pomelo × Duncan grapefruit:	
All the 3 plants planted (6–19–34) in Lipa plot 15 died.	
44. 3442 Siamese × Marsh grapefruit:	
2 Sdgs., E.G. Ext.: R2 T8 and T10	5–30–34
45. 3442 Siamese × Panuban grapefruit:	
1 Sdg., L15: R14 T3	5–26–34
1 of No. 1 on S. O., E.G. I: R27 T16	5–29–34
1 of No. 1 on S. O., L15: R6 T14	5–26–34
3 of No. 4 on 3442 Panuban L16: R14 T8 to T10	6–19–34
3 of No. 5 on 3442 Panuban L16: R15 T4 to T6	6–19–34
1 of No. 1 on S. O., L16: R13 T7	6–19–34
2 of No. 41 on S. O., E.G. Ext.: R1 T4 and T6	5–30–34
46. 3442 Siamese × Pink pomelo:	
3 Sdgs., E.G. I: R19 T2, 11 and T15	6–30–36
1 of No. 2 on S. O., E.G. I: R25 T15	5–29–34
2 of No. 3 on 3442 × Pink, E.G. I: R26 T12 to T13	5–29–34
1 of No. 2 on S. O., L15: R2 T6	5–26–34
1 of No. 3 on 3442 × Pink, L15: R3 T11	5–26–34
3 of No. 1 on S. O., L16: R14 T5, 7 and 13	6–19–34
1 of E.G. Ext. R4 T11	5–30–34
1 of No. 1 on Pom. E.G. Ext. R2 T11	5–30–34
2 of No. 1 on S. O., E.G. Ext. R2 T14 and 15	5–30–34
3 of No. 4 on 3442 × Pink E.G. Ext.: R3 T2, 3 and 4	5–30–34
3 of No. 6 on 3442 × Pink, E.G. Ext.: R3 T5, 7 and 8	5–30–34
3 of No. 7 on 3442 × Pink E.G. Ext.: R3 T10, 12 and 13	5–30–34
4 of No. 10 on 3442 × Pink, E.G. Ext.: R4 T1, 3, 6 and 7	5–30–34
47. 3442 Siamese × Saigon pomelo:	
7 Sdgs., E.G. I: R19 T1, 3, 4, 7, 8 and T10	7–20–33
10 Sdgs., L15: R1 T14; R2 T1, 3, 4, 9 to T14	6–21–33
1 of No. 4 on N. E. × 3442, L15: R6 T11	6–21–33

	Date planted
48. 3442 Siamese × Vermillion pomelo:	
14 Sdgs., E.G. I: R20 T1 to T14	7–21–33
13 Sdgs., L15: R1 T1 to T15, R15 T1 to T3	6–27–33
1 of No. 9 on S. O., L15: R6 T2	6–27–33
3 of No. 10 on S. O., L15: R6 T3 to T5	6–27–33
2 of No. 11 on S. O., L15: R6 T6 and T7	6–27–33
1 of No. 14 on S. O., L15: R6 T8	6–27–33
49. Kussaie × Native lime—*C. aurantifolia* cross:	
4 Sdgs., E.G.P.B. Shed Sec. Nos. 5, 7, 8 and 25	8–12–36

C. Interspecific Crosses

50. Calamonding × Szinkom—*C. mitis* Blanco × *C. nobilis* Lour

Hybrids hard to distinguish from apogamous seedlings, thus all were discarded.

51. Calamonding × Ladu—as above.	
10 Sdgs., E.G. II: R29 T2 to T11	6–25–36
10 Sdgs., Border II: R20 to R29 T1s	6–26–36
52. King × Dougat orange—*C. nobilis* Lour × *C. sinensis* Osbeck:	
6 Sdgs., E.G.P.B. Shed Sec.	7–16–37
53. Kussaie lime × Eureka lemon—*C. aurantifolia* × *C. limonia:*	
3 Sdgs., E.G.P.B. Shed Sec. Nos. 1 to 3	8–12–36
54. Kussaie lime × Rough lemon—same as above:	
All the 7 hybrid seedlings produced died of citrus canker in the nursery.	
55. Ladu × Laurel orange—*C. nobilis* Lour × *C. sinensis:*	
The seedlings are still small (8–31–38)	
56. Magnun ronum × Rough lemon—*C. sinensis* × *C. limonia:*	
Out of 27 seedlings 24 had survived and only 10 remained in the nursery (8–31–37).	
57. Rough lemon × Sour orange—*C. limonia* × *C. aurantifolia:*	
6 Sdgs., E.G. II: R28 T3, 5, 8 to 11	6–25–36
58. Szinkom × Calamonding—*C. nobilis* Lour × *C. mitis:*	
7 Sdgs., E.G. II: R4 T2 to T7, 9 and 10	6–18–36
2 Sdgs., E.G.P.B. Shed Sec. No. 6 and 9	6–12–36
11 Sdgs., Coöp. C. Tamisin Sec. I R9 T3 to T8 and R10 T1 to T5	8–13–36
59. Szinkom × Laurel orange—*C. nobilis* Lour × *C. sinensis:*	
9 Sdgs., E.G. II: R17 T2 to T9 and T11	6–24–36
1 Sdg., E.G.P.B. Shed Sec. No. 32	7–17–36

	Date planted
60. Szinkom × Rough lemon—*C. nobilis* × *C. limonia:*	
8 seedlings in the nursery (8–25–38).	
61. Villafranca × Bahia orange—*C. limonia* × *C. sinensis:*	
4 Sdgs., E.G. I: R11 T12, 14, 15 and 16	7–11–33
1 Sdg., L15: R3 T13	6–28–33
2 Sdgs., L15: R13 T14 and T15	7–14–33
5 of No. 3 on Florida orange, L15: R7 T1 to T5	6–27–33
62. Villafranca × Kussaie—*C. limonia* × *C. aurantifolia:*	
2 of No. 12 on pomelo, E.G. I: R15 T15 and R18 T8	5–28–34
1 of No. 21 on S. O., E.G. I: R18 T10	5–28–34
2 of No. 19 on S. O., E.G. I: R23 T11 and T12	5–29–34
3 of No. 21 on pomelo, E.G. I: R23 T13 and T14, R24 T9	5–29–34
63. Villafranca × Native lime—*C. limonia* × *C. aurantifolia:*	
One seedling planted in pot as of	8–31–37
64. Villafranca natural hybrids with pomelo:	
1 of No. 1 on 3442 × Pink E.G. I: R24 T12	5–29–34
65. Villafranca × N. Ecija pomelo—*C. limonia* × *C. maxima:*	
6 Sdgs., E.G. I: R11 T1, 2, 7, 8, 9 and 11	7–11–33
2 Sdgs., E.G. I: R16 T11 and 13	7–21–33
4 Sdgs., L15: R3 T5 to R8	6–29–33
3 of No. 21 on pomelo, L5: R7 T6 to T8	6–27–33
66. Villafranca × R. lemon:	
Only one remaining in the nursery (8–31–38).	
67. Washington Navel × Laurel orange:	
Out of 20 only 3 remained in the nursery (8–31–38).	
68. 3442 Siamese × Dougat orange—*C. maxima* × *C. sinensis:*	
32 Sdgs. in the nursery near P. B. Shed (8–31–38).	
69. 3442 Siamese × Du Roi—as above:	
24 Sdgs. in the nursery P. B. Shed (8–31–38).	
70. 3442 Siamese × Florida S. orange—*C. maxima* × *C. aurantifolia:*	
Of the 42 seedlings in the nursery planted 6–23–35 only 9 survived as of	8–25–38
71. 3442 Siamese × Laurel orange—*C. maxima* × *C. sinensis:*	
4 of No. 1 on 3442 × Laurel orange, L16: R15 T7 to T10	6–19–34
2 of No. 2 on 3442 × Laurel orange, L16: R14 T11 and T12	6–19–34
3 of No. 2 on 3442 × Laurel E.G. Ext.: R1 T7, 8 and 9	5–30–34
1 of No. 3 on S. O., E.G. I: R24 T15	6–19–34
2 of No. 6 on Sz., E.G. O: R14 T11 and T15	5–15–34
3 of No. 30 on S. O., L16: R15 T11 to T13	6–19–34

	Date planted
72. 3673 Siamese × King—*C. maxima* × *C. nobilis:*	
7 Sdgs., E.G. I: R10 T6, 8, 9 and T13	7–11–33
R17 T6 to T8	7–20–33
2 Sdgs., L15: R3 T19 and T12	6–28–33

NOTE: E.G.I. = Economic Garden Trial Orchard No. 1.
E.G.P.B. Shed Sec. = Economic Garden Plant Breeding Shed Section.
Coop. = Cooperative trial planting.
Sdgs. = Seedlings.
L15. = Lipa Plot No. 15.
Bm. = Batangas mandarin.
Sz. = Szinkom.
R5 T1 = Row 5 hill No. 1.
R1 or R1 = Rough lemon.
Border II = Border of Trial Orchard No. 2.
S O: = Sour orange.

ILLUSTRATIONS

PLATE 1

FIG. 1. Partial view of the citrus hybrid trial orchard, plot 15, Lipa Coffee-Citrus Station, Lipa, Batangas.
2. Another partial view of plot 15.

PLATE 2

FIG. 1. Partial view of Experimental Citrus Orchard No. 1, Economic Garden, Los Baños, Laguna.
2. Left, Kishiu mandarin, notable for its excellent crown but a shy bearer; right, Szinkom mandarin loaded with fruits. Photographed 1931. Tanauan Citrus Station, Tanauan, Batangas.

PLATE 3

Szibat (Szinkom × Batangas) hybrid No. 2, top-worked in August, 1932. Began fruiting in 1935. Note the improved crown. See also Plate 8.

PLATE 4

FIG. 1. A closer view of a branch of Szibat hybrid No. 2 (see Plate 3).
2. Szibat hybrid No. 15. Top-worked on September 29, 1933, began fruiting in 1937.

PLATE 5

Fruits of different varieties. *1.* Szinkom, *2.* Batangas, and *3.* Szibat hybrid No. 2.

PLATE 6

FIG. 1. Szibat hybrid No. 13 on Bm. stock, planted June, 1933. Note the broad leaves in contrast to the narrow leaves of the Szinkom seed parent.
2. King mandarin on Bm. stock in second bearing, with 139 fruits. A very promising variety for commercial planting.

PLATE 7

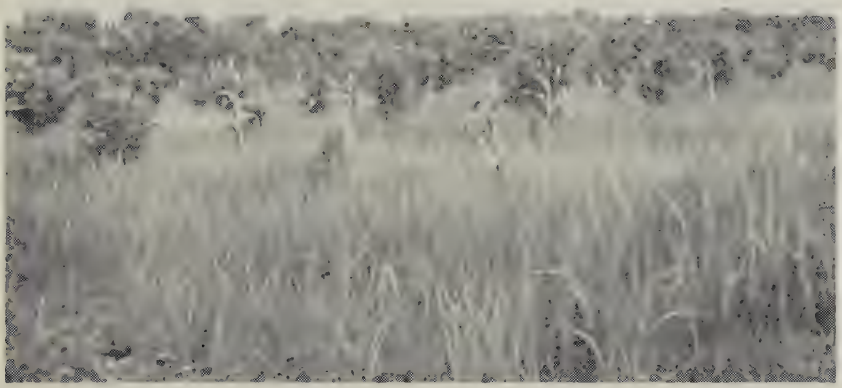
FIG. 1. King–Batangas hybrid No. 11 on Bm. stock. Planted June, 1933. Tanauan Citrus Station, Tanauan, Batangas.
2. King–Kishiu hybrid No. 56 on Bm. stock. Planted July 1, 1936. Economic Garden, Los Baños, Laguna.

PLATE 8

FIG. 1. Kishiu–King hybrid No. 2, top-worked on Bm. stock June 19, 1934. Fruited in 1938. Note the characteristic improved crown of the Kishiu parent.
2. Szinkom–Tison hybrid No. 9 on Bm. stock, planted June, 1933. Flowered in 1938. No fruit yet. Note the improved crown.

PLATE 9

FIG. 1. A 5-year-old King mandarin orchard, distanced 4.5 meters in the rows, with ipil-ipil, *Leucaena glauca* L., for covercrop.
2. Left, seedlings with double-root systems; right, seedlings with single-root systems.



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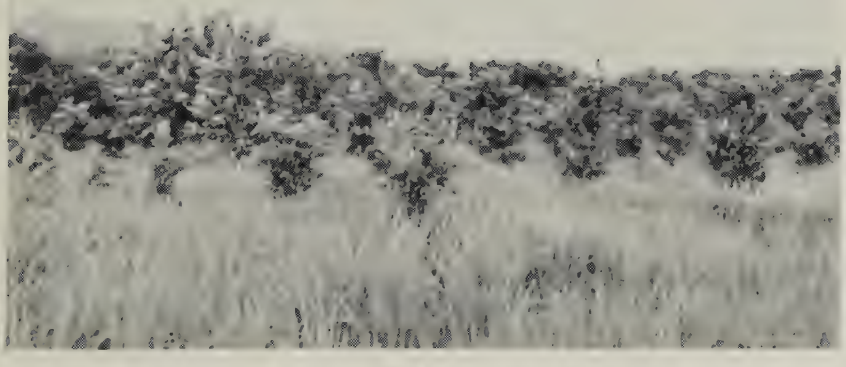

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PLATE 1.

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PLATE 2.

PLATE 3.

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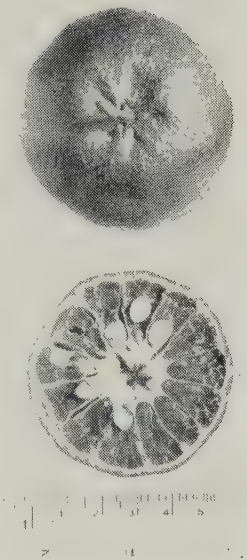
PLATE 4.



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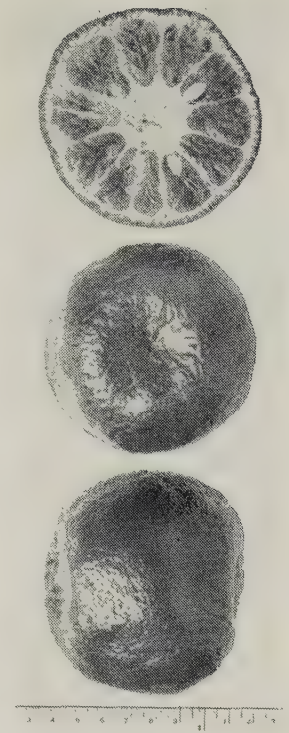

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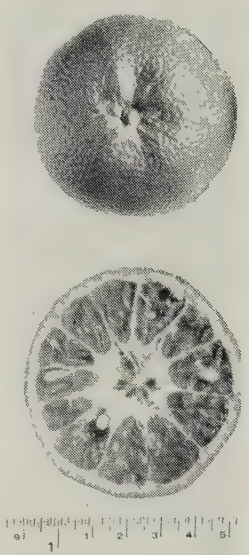

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PLATE 5.

1

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PLATE 6.

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PLATE 7.

1

2

PLATE 8

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2

PLATE 9.

A COMPREHENSIVE STUDY ON SYMPTOMS OF ABACÁ MOSAIC [1]

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Of the Bureau of Plant Industry

NINE PLATES

The present paper deals with a study on symptoms of abacá mosaic. This work was started in March, 1938, with the end in view of bringing to light a vivid picture of a mosaic-infected abacá plant. And also, to make the abacá farmers familiar with the disease. Since abacá mosaic was first reported by the writer(1) in 1934, nobody as yet has given a full description of the symptoms of the disease. Recently, however, Ocfemia and Celino(5) described the symptoms of mosaic on abacá plants but the description was only confined to seedlings which they used in their aphid-transmission experiment.

Although the importance of this work was only recently realized, constant observation by the writer and contact with diseased plants for the last six years, afforded at least, sufficient background in taking notice of the different variations in symptoms as they actually occur in the field. At this juncture, it is not amiss to state that the symptoms which are being described and discussed to a greater extent hereunder have given additional information and more comprehensive description (than the writer's(1) previous and earlier observations) on the disease. It is, therefore, hoped that the presentation of this paper would serve further than merely elucidating the previous work and observations of the writer.

This investigation was made in Davao, supplemented by periodical observations in the Plant Pathology greenhouse of the Bureau of Plant Industry at Manila.

GENERAL CONSIDERATION ON SYMPTOMS

The general characteristic features of a mosaic-infected abacá plant are singularly distinct from those manifested by other abacá diseases. For this simple reason it can be identified correctly without confusion. Anyone with a normal vision and well acquainted with the disease can readily recognize a seriously

[1] Read before the Fifth Philippine Science Convention held on February 22, 1939.

infected plant at a distance of from 10 to 30 feet by merely looking at the leaves. The disease possesses all the characteristic aspects of mottling due to mosaic while a normal leaf is apparently green with a more or less uniform distribution of the chlorophyll.

The abacá plants are attacked by mosaic in all stages of its growth, that is, from the time the plant emerges from the ground up to maturity. It is not unusual to find diseased mother plants produce or bring forth mosaic-infected daughter plants. Also, abacá rootstocks or suckers from mosaic-infected mother plant or stools, when planted, almost invariably produce mosaiced abacá. Having in mind the systemic nature of the disease and the relationship between the daughter and parent plants, the writer has adopted the term *intrinsic* infection for any infection that may have been acquired by the daughter plants direct from the diseased mother plants. On the other hand, for any infection which may have come from extraneous sources—perhaps through the agency of certain insect vectors(2), (5)—the term *extrinsic* infection was designated. Magee as mentioned by Wardlaw(6) called it *primary* and *secondary* to indicate respectively these two forms of infection on banana by bunchy-top in Australia.

Not all plants in a mosaic–infected stool may show the symptoms of the disease. Sometimes only one, two or three diseased plants may be found infected in a stool of 25 to 30 plants. In severe cases, however, all plants in a hill, regardless of its size, may be infected with mosaic. Those seemingly healthy plants in a partly diseased stool are found not advisable to use as planting materials. The risk lies in the fact that since the disease is systemic in nature, the virus might be present, but sufficient time has not yet elapsed before the symptoms appear. Or, it might be that, externally, the plant appears healthy but the symptoms are masked or still obscure to render them visible to the naked eye. When such materials are planted the mosaic disease is likely to be carried over to new plantings.

Where bunchy-top is also prevalent in a mosaic-infected locality the two diseases may occur simultaneously on the same plant. Under this condition both the bunchy-top and the mosaic symptoms are manifested in one individual plant. The necessity of proving further the existence of these two diseases on one plant in future experiments is, therefore, in order. It was noted(3) that in a field where both mosaic and vascular wilt disease ex-

isted, these two diseases were found attacking the same plant. However, no case has as yet been found wherein a combined attack of the three diseases, namely, the mosaic, the bunchy-top and the vascular wilt occurs in one plant.

In 1931, the writer observed that in some plantations in Davao, wild canna, *Canna indica* Linn. was infected with mosaic. It was found side by side with or in close proximity to the mosaiced abacá as shown in Plate 9. The symptoms on the canna and on the abacá were similar in appearance (Plate 9).

Under the conditions obtaining in Davao the extent of mosaic infection varies from slight to severe in certain individual fields. At present the seat of serious infection is found in Lasang, Davao. Although the foci of infection are dissipated here and there all over the entire abacá–growing localities in Davao and partly in Cotabato, it appears that the disease, in low places, is more serious now than uphill. In certain low places, the disease has so spread as to constitute an epidemic causing the abandonment of some plantations. Actual count of healthy and mosaic-infected stools belonging to Southern Davao Development Company, Lasang, Davao has demonstrated that in a plantation 6 to 8 months old, the infection was 59.41 per cent. Where the plantation was 2 to 3 years old, the infection was 60.22 per cent; 7 to 8 years old, 62.45 per cent.

So far, no cases of recovery have been observed among diseased plants both in the field and in the greenhouse. Diseased plants, especially those infected intrinsically may die a premature death while other plants, however, may continue to grow until the fruiting stage is reached. In cases like this, the symptom of mosaic disease is traceable to the flowers (Plates 5 and 6) and fruits (Plate 7). Of the 2,775 abacá seeds from diseased fruits that were planted in closed cages, 880 seedlings germinated but not a single plant showed symptoms of mosaic after a period of 8 months. Based upon this result, the probability is, that the abacá mosaic virus is not carried over through the seeds.

Diseased stalks when already mature are also strippable like the normal ones but as to whether or not the productivity of the plant and the tensile strength of the fibers are affected remain to be investigated. It might be of interest to note that the three varieties of abacá grown commercially in Davao, namely, Tañgoñgon, Maguindanao, and Boñgolanon, are all subject to mosaic infection.

Based on the foregoing discussion and the writer's previous observation in 1934(1) it is believed that the mosaic disease of abacá in the Philippines is similar to, if not closely identical with, the new virus disease of banana reported by Magee(4) in Australia.

SYMPTOMS

On the foliage.—The first external indication of mosaic infection is the appearance of spindle-shaped patterns on the nether surface of the leaf running in the same direction as the veins (Plate 1, fig. 1, left side of the leaf). This characteristic incipient symptom may be noted simultaneously with the clearing of the veins in between them as shown on the right side of the leaf (Plate 1, figs. 1 and 2). The spindle-shaped pattern varies in size, ranging from 20–30 millimeters long by 2–3 millimeters wide. This consists of light chlorotic linear areas forming irregular and broken stripes from the midrib to the leaf margin. Sometimes anastomosing of the spindle-shaped pattern may take place (Plate 1, fig. 1). On the center of the spindle-shaped pattern may occasionally appear a sort of a green dot or speck simulating an "island." Toward the long axis of this "island" may radiate a short fine line of green color with one end pointing to the midrib, the other running toward the leaf margin. Sometimes this green speck or "island" assumes also the shape of a spindle (Plate 1, fig. 1, left side of the leaf). In the early stages of the disease, the spindle-like streak is found in localized portions of the leaf area. Two or more of them may coalesce or fuse laterally, or may join together end to end to form larger or longer composite chlorotic areas as the case may be (Plate 1, fig. 1, left side of the leaf). The color may also vary. Ordinarily the spindle-like streak appears yellowish pale green although at times it may have rusty appearance. The rusty color may be noted on the blade, midrib, and petiole of the leaf.

On the unfurled leaves the mosaic patterns are oftentimes decidedly delineated—the pale yellowish green contrasting sharply with the normal green. On the youngest folded leaf the characteristic symptom of mosaic infection is the presence of ring-like bands of yellowish streaks alternating with wider normal green stripes. Sometimes these ring-like streaks consist of fine threads of vivid green alternating with wider bands of light yellow color.

Cases have been observed where the mosaic-infected leaf was followed by an apparently healthy leaf. Under this condition, it is believed that the symptoms might have been masked with

something not yet well understood. Later on, however, the symptoms may reappear on the succeeding leaves. It was further observed that in some occasional instances the subsequent leaf that followed the first infected one showed less distinct mottling. Ordinarily, however, the opposite is true, that is, the leaf that follows the infected ones is severely chlorotic and disfigured by a more pronounced mottling.

Infected leaves are sometimes corrugated to form irregular depressions. No case has as yet been observed either in the field or in the greenhouse where infection works backward, that is, the old normal leaves produced prior to the manifestation of mosaic symptoms remain normal green. This is due perhaps to the cessation of growth on the older leaves.

On the midrib and petioles of the leaf.—Cases have been observed where the first sign of mosaic infection appeared on the midrib while the leaf blade was apparently normal. The presence of light yellow or orange streaks on the midrib is indicative of mosaic infection. The subsequent leaf may show more distinct and elongated yellowish streaks both on the petioles and midrib although no mottling on the leaves may be traced. The next ensuing leaf may show the characteristic mottling of the petioles, midrib and leaf blade. It was observed in most cases that when the petioles of the infected leaf appeared salmon or somewhat rusty in color, the inner tissues usually became discolored or necrotic. In a more advanced stage of the disease gradual blackening and dying of the tissues also took place.

The streaks on the midrib and petioles vary in size and shape (Plate 2, figs. 1 and 2, and Plate 3). They appear dark green with yellowish background as shown distinctly in Plate 3. The long axis of the dark green streak runs from the base of the petiole towards the tip of the midrib.

On the stalk or pseudostem.—The symptoms on the stalk or pseudostem of a diseased abacá are oftentimes hard to find especially when the plant has attained maturity probably because of the dominating natural dark brown to purple color of the outer and most exposed portion of the stalk. However, as the outermost leaf sheath is removed to expose the next layer, which is usually lighter in color, the mosaic symptom, if there is any, becomes seemingly evident (Plate 4). It is characterized by the presence of spindle-like streaks running longitudinally toward the long axis of the pseudostem (Plate 4). Again, the mottles vary in shape, size and color. The color ranges from yellowish white to purplish streaks. In some cases, a small dot

or elongated "island" may be seen on the center of the spindle-like pattern (Plate 4). Similar to the mode of mottling on the leaves, two or more streaks on the stem may coalesce laterally or fuse on either ends to form larger or longer streaks as the case may be. In a certain case examined, mottling on the stalk is apparent up to the fourth inner leaf sheaths. On young plants the natural color of the stalk is usually green so that the patch-like mottling becomes readily discernible (Plate 3).

Symptoms on the inflorescence or "heart."—Healthy mother plants produced healthy inflorescences or "hearts." On the other hand, mosaic-infected plants invariably produced diseased flowers. This was observed in a badly infected plantation in Lasang, Davao. It was noted that a newly emerged inflorescence of a mosaic-infected abacá plant might show the characteristic symptoms of mosaic disease (Plate 5). The mottling condition appears very distinctly on the outside part of the bracts rather than on the inside. It is due perhaps to the subdued color of the latter. Mosaic-infected "heart" manifests the presence of yellowish light green streaks radiating from the base to the tip of the bracts (Plate 5). As shown in Plate 5, the light color represents yellowish light green streaks, the darker manifests the natural reddish coloration of the bract.

The male flowers are shown in Plate 6, figs. 1, 2, and 3. The characteristic appearance of mosaic disease on the inflorescence simulates that which is found on the pseudostem. The presence of spindle-shaped streak is very evident (Plate 6, figs. 1 and 3). It radiates from the base towards the tip of each bract. Two or more of those spindle-shaped streaks may coalesce along the sides or at either ends to form a larger or longer mottling as shown in Plate 6, figs. 1 and 3. The mottling becomes apparent up to the innermost bract of the infected flower. On the other hand a normal inflorescence (Plate 6, fig. 2) does not exhibit any mottling on its bracts. When the infected bracts are removed one after the other they leave distinctly discolored scars on the rachis (Plate 6, fig. 3). On the other hand the scar left by the healthy bract is perfectly white and healthy (Plate 6, fig. 2). A cross-section of a mosaic-infected rachis showed distinct brownish discoloration on the epidermal tissues and also in some portions of the endodermis.

Symptoms on the fruits.—Diseased fruits show also the characteristic mottling but it is not readily discernible at long range. It constitutes violet wedge-shaped streaks and may be seen on four sides of the finger (Plate 7, fig. 1).

The fingers in a diseased hand do not all exhibit decided mottling. Some may exhibit more distinctly than the others. On the other hand, a normal finger never shows any mottling as shown in Plate 7, fig. 2. The green color of the skin is more or less uniform. When the mosaic infected fruit is cut open the inner tissues appear brown while those in a normal finger are perfectly white and healthy. The brownish coloration is usually found on the epidermal cells. In some cases, although not too often, sterility and decaying of mosaiced fruits were noted (Plate 7, fig. 1).

The characteristic mottling on the foliage, midribs, petioles pseudostems, inflorescences, and fruits; the transmission of the disease systemically to new plantings either through mosaic-infected sucker or suckers from diseased stools; and the inability of diseased plants to recover once they become infected are very strong presumptive indications, that the disease may be classified under the group of infectious chlorosis.

SUMMARY

The present paper is an exhaustive study on symptoms of mosaic disease of abaca in Davao. Symptoms of the disease on the leaves, midribs, petioles, pseudostem, inflorescence, and fruits are described.

ACKNOWLEDGMENT

The writer is profoundly grateful to Dr. Feliciano M. Clara, Chief of the Plant Pathology Section for valuable criticisms offered during the progress of this work and to Mr. Crispiniano C. Hernandez, Junior Plant Sanitation Inspector in charge of the Plant Quarantine Service in Davao for furnishing the necessary plant materials for the investigation.

LITERATURE CITED

1. Calinisan, Melanio R. A suspected "mosaic" of abacá in the Philippines. Phil. Jour. Agr. 5 (1934) 255–257, pl. 1.
2. ——— Transmission of abacá mosaic (Progress Report No. 1). Phil. Jour. Agr. 9 (1938) 309–313, pls. 1–3.
3. ——— Vascular disease of abacá (Manila hemp) in Davao (Progress report No. 1). Phil. Jour. Agr. 9 (1938) 153–160, pls. 1–11.
4. Magee, C. J. A new virus disease of bananas. Agr. Gaz. N. S. W. 41 (1930) 929.
5. Ocfemia, G. O. and Martin S. Celino. Transmission of abacá mosaic. Philippine Agriculturist 27 (1938) 593–598, figs. 1–2.
6. Wardlaw, C. W. 1935. Diseases of the banana and of the Manila hemp plant. XII + 615 p. London: Macmillan and Co., Ltd.

ILLUSTRATIONS

Plate 1

[Photographed by the Photographic Division, Bureau of Science, Manila]

Fig. 1. A portion of the first infected leaf of abacá plant showing the characteristic incipient symptom of mosaic disease. Note the spindle-shaped pattern on the left side of the leaf running almost parallel to the veins. Note also the clearing of the veins on the right side of the leaf blade.

2. A portion of the second subsequent infected leaf of the same abacá plant shown in Fig. 1. Note the more advanced symptom of the disease. Examine very carefully the mottling appearance of this second leaf and compare it with the first. The lighter color is yellowish pale green and the darker, normal green. Note also that the clearing of the veins on the right side of the leaf (Fig. 2) is more distinct than that in Fig. 1.

Plate 2

[Photographed by the Photographic Division, Bureau of Science, Manila]

Fig. 1. Upper surface of the abacá leaf infected with mosaic disease. Note the characteristic mottling of the leaf blade and the midrib and compare it with that in Fig. 2.

2. Lower surface of the same leaf shown in Fig. 1. Note the characteristic mottling of the leaf blade and the midrib and compare it with that in Fig. 1.

Plate 3

[Photographed March, 1938, Davao City]

Upper portion of the pseudostem of a mosaic-infected abacá plant showing the various shapes of patch-like shades which are the characteristic symptoms of mosaic disease.

Plate 4

[Photographed March, 1938, Davao City]

A portion of a mature pseudostem showing the symptoms of mosaic disease. Note the characteristic spindle-shaped marks or mottled areas running toward the long axis of the pseudostem.

Plate 5

[Photographed March, 1938, Davao City]

A newly emerged inflorescence or "heart" of a mosaic-infected abacá plant showing the symptoms of mosaic disease. Note the characteristic mottled appearance as shown clearly on bracts 1, 2, and 3.

PLATE 6

[Photographed April, 1938, Davao City]

FIG. 1. Male inflorescence or "heart" of abacá plant infected with mosaic disease. Note the spindle-shaped mottling on the bracts and compare it with Fig. 2.

2. A healthy male inflorescence or "heart." Note the absence of mottling on the bract and compare it with Figs. 1 and 3.

3. Mosaic-infected male inflorescence or "heart" of abacá plant with a portion of the rachis. Note that the bract scars as indicated by the arrow on the rachis show also symptoms of mosaic disease. The bracts are also badly mottled.

PLATE 7

[Photographed April, 1938, Davao City]

FIG. 1. Young green fruits of abacá plant infected with mosaic disease. The whole bunch is called a "hand" and one fruit is called a "finger." Note the spindle-shaped mottling on the "fingers." Note also the discoloration at the point of attachment of the hand to the rachis and compare it with Fig. 2.

2. A healthy bunch of abacá fruits or "hand" from a healthy abacá plant. Note the absence of mottling on the "fingers" and compare it with Fig. 1.

PLATE 8

[Photographed April, 1938, Davao City]

Abacá suckers showing the after-effects of early mosaic infection. Note the partial deformities and stunted growth of the plant. Note also the fan-like appearance of the leaf sheath.

PLATE 9

[Photographed by courtesy of Mr. Kojima of Ohta Development Co., Davao]

Cannas, *Canna indica* Linn. infected with mosaic disease. Note a hill of abacá in the background which is also infected with mosaic.

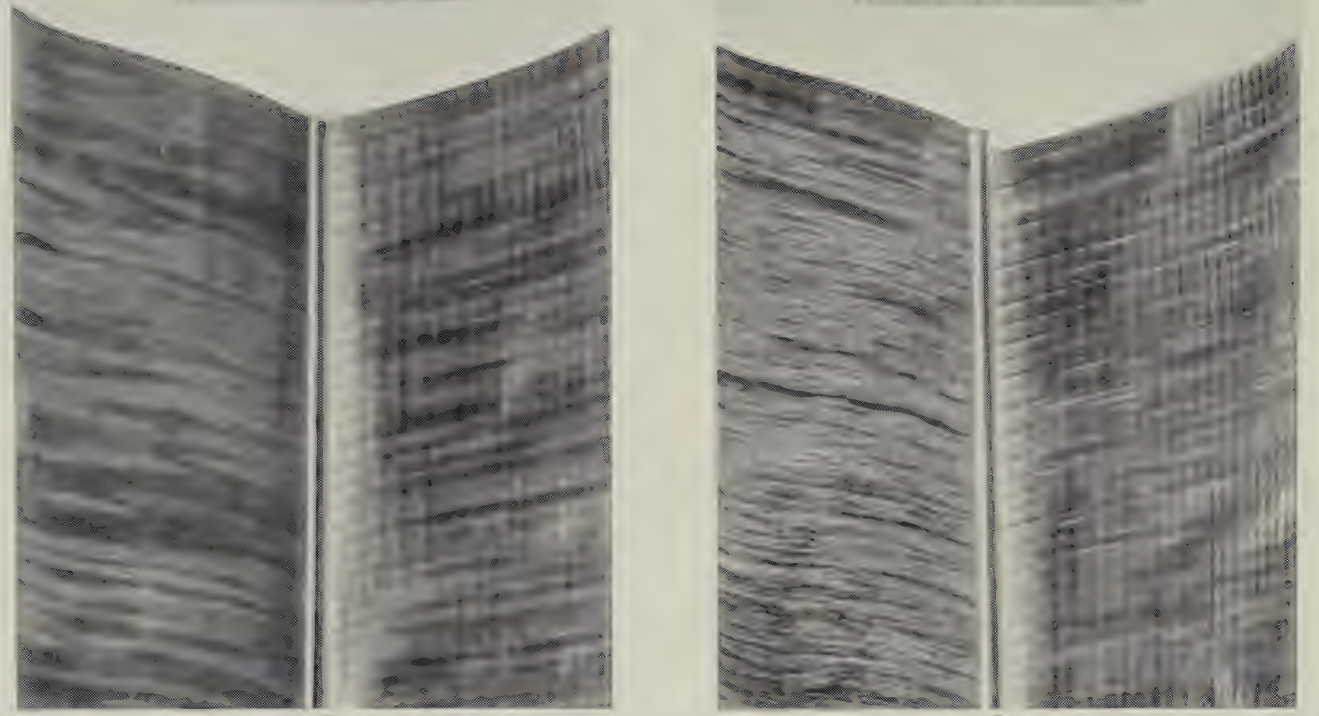
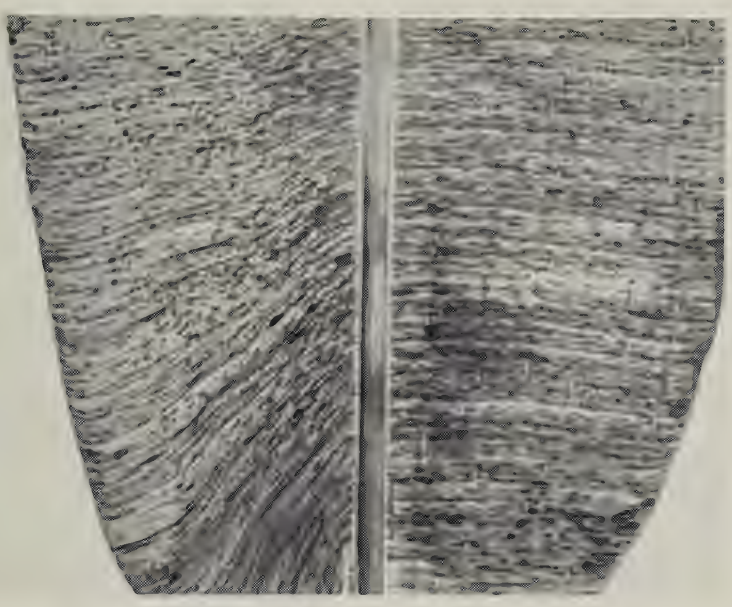


PLATE 1.



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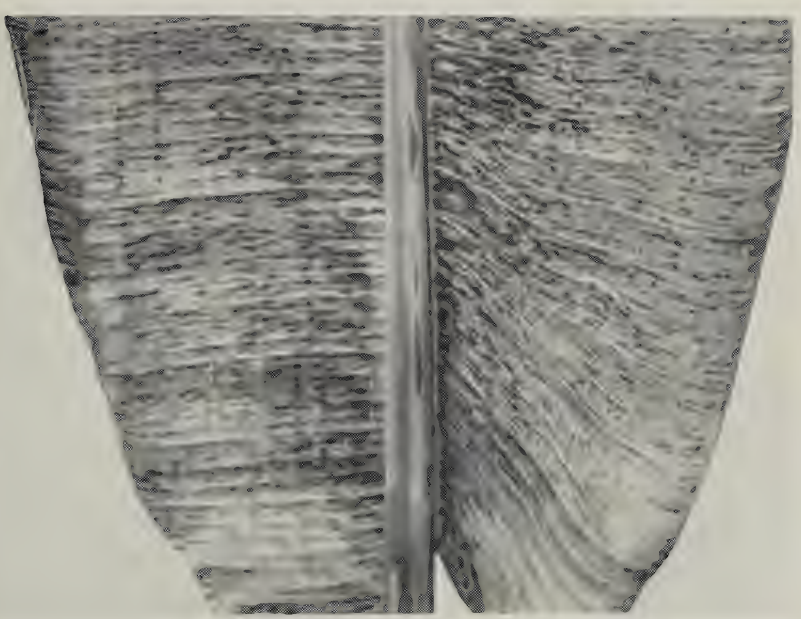

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PLATE 2.

PLATE 3.

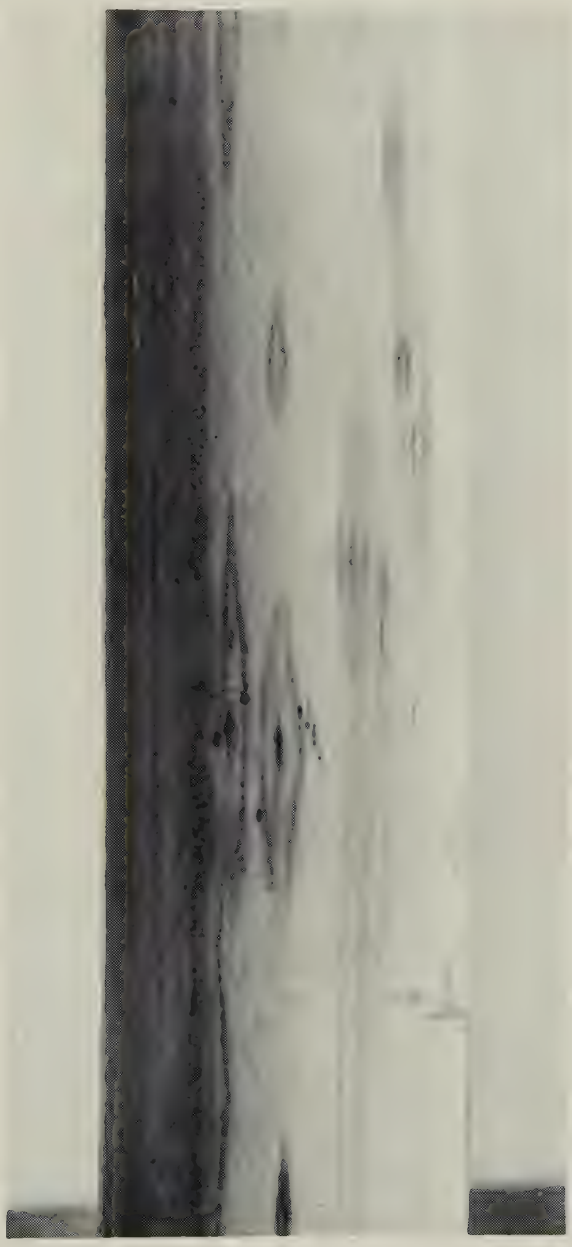

PLATE 4.

PLATE 5.

PLATE 6.

1 2

PLATE 7.

PLATE 8.

PLATE 9.

NOTES ON BUD DIFFERENTIATION IN CARABAO MANGO (*MANGIFERA INDICA* L.)[1]

By Epitacio A. Lanuza

Of the Horticulture Section, Bureau of Plant Industry

SEVEN PLATES

The present article consists of a study on bud differentiation in carabao mango before and during the flowering season, from February, 1937 to January, 1938. It, however, includes some previous observations made by J. A. Agati and E. O. Olivares during the mango seasons of 1933–1936.

Originally this work was conceived by Dr. M. L. Roxas, then Director of the Bureau of Plant Industry and by F. G. Galang, at present Chief of the Horticulture Section of the same Bureau and was intended as a "charter" in a series of studies on bud differentiation in all mango varieties in the Philippines, and eventually other fruit trees. In 1935, or just after the work[2] was well under way an article on the same subject by Alcala and San Pedro(1) of the College of Agriculture, University of the Philippines, appeared in the *Philippine Agriculturist*. While the article referred to may be of great interest to scientists it did not, however, treat of the practical phases involved in bud differentation which may be of value to mango growers. This paper aims, therefore, not only to confirm conclusions drawn by previous investigators but also to throw more light on certain points still remaining obscure which may lead to direct application in horticultural practice.

REVIEW OF LITERATURE

It has already been known that fruit bud formation, on which fruit production depends, is influenced by a number of orchard practices such as cultivation, irrigation, pruning, smudging, etc. Furthermore, it has been found by Bradford(4) that fruit buds are formed in the summer previous to their blossoming. It was

[1] Prepared with the advice of Mr. F. G. Galang, Chief, Horticulture Section, Bureau of Plant Industry.

[2] Mr. J. A. Agati and Mrs. E. O. Olivares made observations both in Novaliches, Rizal and in Central Experiment Station, Singalong, Manila.

Goff,(10) (11) however, who first recognized definitely the initial stage of flower bud formation in deciduous orchards.

In the Philippines a method called smudging has been evolved to induce mangoes to flower. Just when mango smudging was first practiced in the Islands cannot be ascertained. Suffice it to say that the practice has been resorted to since time immemorial in some provinces of the Islands, particularly Bataan, Bulacan, Cavite, Pampanga, and Rizal. The first record on the subject is by Wester(19) followed by Galang(7) Gonzales(13) and Galang and Agati(8) (9) in the order given.

Although already an established fact that mango buds are easily activated in producing flowers by smudging, there are cases observed by the writer as well as by other workers as Alcala and San Pedro(1) and Galang and Agati(9) whereby activated buds turn out foliar instead of floral flushes.

Smudging, although apparently effective in inducing flowering, is not only laborious but also expensive. In spite of such costly operation and hazards, however, some farmers at times continuously smudge their trees even for over a month not only because of ignorance of the proper stage for smudging but also because of fear of reversion.

A belief common to a number of mango owners is that leafy shoots develop instead of flower shoots if smudging is stopped before the inflorescence becomes clear to the naked eye. Alcala and San Pedro(1) doubt such an occurrence as long as buds have already differentiated. Goff(10) believes that there is little reason to suppose that there could be reversion of flower buds. He says that the failure of apple and pear orchards to bloom is not due to reversion but most probably to failure in forming flower buds.

In passing it may be mentioned that another belief entertained by a few farmers is that there are certain pre-flowering characteristics prior to flower formation. Although such a behavior has been ascertained in some kinds of fruit trees, it has not been recorded or established in mangoes. Drinkard(6) for instance reports that the first corrugation on the crown (of buds) of Olderberg apple indicates floral formation. In Ball's(2) treatise on the time of differentiation and the subsequent development of the blossom bud of plum, he quoted Dr. Beale as follows: "Before December, by the bluntness of the bud you may discover what branch will bear fruit the next season immediately after flowering." A casual observation made by the

writer on avocado trees at La Granja while assistant superintendent of the Granja Sugar Cane Experiment Station at La Carlota, Occidental Negros, was that some avocado trees exhibited greater waviness of mature or maturing leaves prior to flowering.

OBJECTIVES OF THE STUDY

The objects of the present study are:

1. To note the external signs as well as the development of leaf buds and flower buds.
2. To determine the internal changes taking place in flower buds and leaf buds and their differences both for smudged and non-smudged trees.
3. To establish such differences so as to reduce, if not altogether avoid, the excessive cost of smudging of some carabao mango trees.
4. Incidentally, to blaze the way for studies on the same or related subjects in some other fruit trees in the Philippines with the object in view of throwing light on proper cultural practices.

MATERIALS AND METHODS

The work was conducted both at the then Singalong Central (now Central Experiment) Station, Manila and Lamao Horticultural Station, Limay, Bataan, of the Bureau of Plant Industry, as well as in Novaliches Mango Orchard, Rizal, on smudged and non-smudged carabao mango trees about 15 years old or more. Prior to this study, these trees had been in bearing for sometime. It might be mentioned in passing that the trees at Novaliches had been pruned and sprayed, some days before smudging, to protect the shoots from the attack of twig borers.

The preliminary field studies were started by Mrs. E. O. Olivares in October, 1933. With the transfer of Mrs. Olivares from the Horticulture Section to the Plant Breeding Section, the work was temporarily stopped. Sometime later, the task was entrusted to the writer, who conducted a systematic study on the subject, employing some of the results already gathered.

It is to be expected that since this was the first work of its kind in the Bureau, many drawbacks and obstacles were encountered at first, such as difficulties due to the presence of hairs in the buds, latex, etc.

Ten trees were selected at Novaliches, Rizal; four at Singalong Central (now Central Experiment) Station in 1937 (5 in 1934) ; and six at Lamao Horticultural Station.

On each tree a number of buds were marked in October or sometime before flowering. This was done by putting rings with the use of white lead paint on the twigs bearing the buds for study. Young twigs (with tender leaves) were marked with two rings, mature ones with one ring. This was done in order to observe how long differentiations in different stages of bud formation would occur.

Biweekly collections of 3 to 6 buds made every time from each tree were put immediately in fixatives [1] consisting of fifty-fifty 50 per cent alcohol and commercial glycerine, and then brought to the Central Office laboratory for detailed macroscopic and microscopic observations.

The first stage and the complete differentiations were determined microscopically while the appearance of flower formation was gauged with the "naked eye."

For organographic studies, cross-sections of buds and dissections of the parts were made. For the detailed microscopic studies, median longitudinal sections were availed of. In making the latter sections two methods were followed: (1) "Free" sectioning (without embedding) by means of a sliding microtome. For rough examinations, sometimes good sections were also obtained with the use of gillete blades. (2) With the use of rotary microtome after embedding the materials in the usual paraffin method as outlined by Chamberlain.(5) While for detailed studies good sections were obtained from those embedded, for histological relations of parts some fairly good sections were also obtained in the free sectioning which were helpful in finding the arrangement of the different parts. Sometimes sections taken after embedding had slight alterations in the arrangements of the tips of both the scales and leaf primordia.

For those used in median sectioning, slabs were taken from opposite sides leaving convenient median sections about 1 mm. to 1.5 mm. thick before they were placed in the killing and fixing reagent and kept therein for a day or two after which they were washed off for embedding.

Materials for embedding, after washing with running water for about 24 hours, were treated in accordance with the method of Chamberlain.(5) Sectionings were made to a thickness of 8 to 10 micra.

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[1] The writer used the following fixative for some specimens especially for dissections: Alcohol (70 per cent) 90 cc.; formalin, C. P. (35 per cent) 6 cc.

The paraffin method offered certain difficulties possibly on account of the hairs on scales and foliar primordia that caused some breakage to the sections. Similar difficulties were experienced by Tufts and Morrow(17) with apple and pear. However, a number of fairly good sections were obtainable for purposes of this study.

Observations were also concomitantly carried out on the trees for pre-flowering characteristics that could be easily distinguishable to the naked eye. For this purpose twigs of the early stages as those in Novaliches (described below) were selected to start with.

BRIEF DESCRIPTIONS OF TWIGS BEARING BUDS AT NOVALICHES, RIZAL, DURING THE PERIOD OF SELECTION OF BUDS FOR USE IN THE STUDY.

Tree I.—Shoots appeared on October 5 but on November 10 they were still tender although the leaves were fully developed. Leaves were light green.

Tree II.—Shoots appeared on October 31 with lengths ranging from 15 to 20 cm. at the time of observation. The leaves were fully developed on November 10 although still tender.

Tree III.—Shoots appeared in October but on November 10 they were still tender. The leaves were fully developed but younger in appearance than those of Tree I. They were light purple.

Tree IV.—Shoots appeared on October 31, of 15 to 20 cm. in length at the time of observation. The leaves ranged from 13 to 15 cm. and were light purple like those of Tree III.

Tree V.—Shoots appeared on October 12; length from 18 to 30 cm.

Tree VI.—Shoots appeared on November 1. On the 10th they were from 15 to 20 cm. long with tender and immature leaves ranging from 7 to 15 cm. each.

Tree VII.—Shoots appeared on October 10 but were almost similar to those of Tree I. On November 10, the shoots were from 18 to 30 cm.

Tree VIII.—On November 9 the shoots were from 14 to 20 cm. in length with 7 to 15 leaves each.

Tree IX.—Shoots appeared on November 3–10. At the beginning of observation, they were still tender with undeveloped leaves, the length ranging from 7 to 10 cm.

Tree X.—On November 9 the shoots were from 14 to 20 cm. in length and had 7 to 15 leaves each.

The different trees as noted above had been briefly described to show the relative stages or ages of the buds at the beginning of the observations.

OBSERVATIONS

The terminal or apical bud in its dormant stage is more or less conically-shaped with either blunt or pointed tips set squarely just above the well-developed leaves of the last flush (Plate 1, fig. 1). Note its organography (Plate 2, fig. 1): S, scale; TS, transition scales; F, foliar primordium; am, apical meristem. Its color (following the terminology in Color Standards and Color Nomenclature by Robert Ridgway) may either be lumiere green with antique brass; light apple green with tips of olive brown, blackish brown, light cacao brown, blackish, sooty, or light brown; spinach green with tips of antique brown, brown, and benzo brown; apple green or dark green with tips of different shade of colors; etc. When they become old, however, the buds turn light brown or blackish brown.

The buds are covered with scales of almost similar form but of various sizes depending upon the girth of the twig on which they are borne, ranging from 2 to 9 mm. at its narrowest portion at the base and 4 to 14 mm. at the widest portion; and from 2 to 6 mm. long from the base of the outermost scale to the tip of the bud.

The scales converge on the top and show an appearance of compactness, clasping tightly the inner parts when buds are in dormancy (Plate 1, fig. 1).

Upon smudging or when further development or growth goes on, the scales most usually become somewhat loose at the tips (Plate 2, fig. 4). Still with further development the inner scales grow longer and slightly wider (Plate 3, figs. 2–16 and Plate 4, figs. 1–17a) at the same time that the scales are progressively shed off from out inward, due perhaps to the growth of the apical meristem as well as of flower cluster primordia from the axils of the inner scales.

In the study of bud differentiation axillary buds have to be considered. Therefore, in the present work they were concomitantly taken.

The structure and arrangement of the different organs of the axillary or regenerative buds (Plate 1, fig. 11) are similar to the terminal ones with the exception of the slightly compressed appearance of the bud and its parts (Plate 1, figs. 11, 15, 18), the outermost scales which are shaped like scales of fish (Plate 1,

figs. 13 and 14), and the lesser number for both the scales, transition scales, and foliage leaves.

Scales.—Microscopical examination shows the seeming simplicity of the vaginate appearance of the scales. The outermost ones are tough and hard with prominent protrusions that are either blunt or pointed with the dorsal scales conspicuously ridged (Plate 1, figs. 2 and 3). The inner ones have their exposed tips brownish or blackish, each one tightly clasping each other and protecting the meristematic tissues inside. Careful examination aided by a good hand lens shows traces of few hairs on these scales which are characteristic of foliage leaves. Every bud scale, at the early stage of development, terminates in an apical protuberance (Plate 1, fig. 1 and Plate 2, fig. 4), a structure corresponding and equivalent to the lamina of a normal leaf. These protuberances are not inhibited even at the advanced or older stage of the scales (Plate 3, figs. 2–16 and Plate 4, figs. 1–17a). This corroborates the findings of Alcala and San Pedro (1) on their work on Pico and Indian mangoes (the Carabao mango tree they worked on did not flower) wherein bud scales are of two distinct parts: (1) the broad sheath or sheath-like structure which forms the greater bulk of the scale, and (2) the laminar primordium which varies in form and size depending upon its position on the bud.

Sheath.—The sheaths on any one bud vary in size, thickness, and to a certain extent, in forms depending upon their relative positions (Plate 3, figs. 2–16; Plate 4, figs. 1–17a). The outer scales are thick, horny, and usually smaller than the few succeeding ones. They are usually triangular or ovate, brown, or blackish and sometimes greenish at the exposed parts and green to light green at the unexposed portion. The margins are thinner than the median portion. Such outer scales with the few inner ones immediately following have dorsal sides of the sheaths often ridged.

Careful examinations would show traces of some few trichomes or hairs on the sheaths that are of combined unicellular and multicellular types, usually of the latter one (Plate 1, figs. 10 and 12), and which are often destroyed or inhibited as the scales grow old or get exposed (Plate 1, fig. 2). The succeeding (inner) sheaths are of variable sizes.

Taken altogether, the scales (sheaths plus their protuberances or primordia) vary from 1.5 to 15 mm. for those of the terminal buds, and 1.2 to 12 mm. for the axillary buds depending upon the size and development of such buds.

Transition scales.—The transition scales usually range from one to three and sometimes more but not over six, depending upon the size and development of the bud. They vary in forms ranging from slightly ovate or ovate-cuspidate at the dormant stage (Plate 1, figs. 4–5 and 16–17) or narrowly cuspidate to thinly elliptic when further development goes on (Plate 3, figs. 14–16 and Plate 4, figs. 15a–17a). At first glance, due to curvature or slight folding of the sides near their tips, they sometimes appear slightly triangular. At the tips are protuberances (laminar primordia) while the ends of the sheaths at close examination are very slightly winged.

At full development the transition scales are decidedly narrow and elongated (Plate 3, figs. 14–16; Plate 4, figs. 15a–17a). A careful examination of these scales reveals some hairs at both margins and at times at the nether surfaces.

Transition scales (sometimes also called transition leaves) measure from 3.6 to 4 mm. long at dormancy and 10 to 20 mm. at full development, and 3.2 to 3.7 mm. wide at dormant stage to 4.2 to 6.5 mm. wide when tender foliage leaves begin to appear at the tips of the bud as for instance when bud development reaches that of figures 2 and 3 of Plate 2.

Foliage leaves.—At their dormant stage, the foliage leaves, as they naturally appear, of both terminal (16 to 20) and axillary (14 to 16) buds are more or less conically-shaped with tips apparently either pointed or blunt, the latter especially true with those of the axillary buds.

The terminal foliage leaves are set more or less squarely on the stem end, the length of these organs decreasing as they go towards the inside or center. They range from 1 to 4 mm. long and from 0.5 to 1.5 mm. wide (Plate 1, figs. 6 and 18).

Dissecting one by one the foliage leaves and examining them closely with the aid of a dissecting microscope would reveal profuse hair at the central ventral portion of each foliage leaf (Plate 1, figs. 8–9 and 19–20). The hairs may both be unicellular or multicellular, mostly of the latter type (Plate 1, figs. 10 and 12). After the removal of the foliage leaves (or foliar primordia) the crown is bared in a short cone-like structure (Plate 1, figs. 7 and 15).

Differences between floral and foliar shoot buds—active—Macroscopical).—Numerous studies and dissections of both kinds of shoot buds reveal a number of interesting points. The most apparent difference at first glance (on advanced stages of buds)

is the extremely "beak-like" and usually very plump appearance of the floral shoot (Plate 2, figs. 5–6) which retains such an appearance for sometime even when the scales have already fallen off and the abortive foliage leaves have fully attained their development (Plate 2, figs. 6 and 10). These foliage leaves which do not even attain one-eighth the size of a normal leaf (Plate 2, fig. 10) fall off upon further development of the flowers they subtend, the leaves serving as primary bracts.

The foliar shoots grow either upright or, if "beak-like," they are not so pronounced as the floral shoots. Moreover, the foliar shoots are quite lean in appearance (Plate 2, fig. 3 and Plate 3, fig. 1). This characteristic is especially true with terminal shoots.

As is clearly shown in the above discussion, such differences become discernible only when the growth of the buds is already quite advanced. At the dormant stage of the buds and even at just the start of differentiation there seems to be no way of differentiating the two kinds of buds unless microscopic studies are carried out and even at that only when floral cluster primordia are already distinguishable.

At the outset, it must be mentioned that examinations of dormant buds, both terminal and axillary, never show any difference until the buds are already on the advanced stage as shown in Plate 2, fig. 5. At such advanced stage, although the two or four outermost scales of the floral bud are not any different from those of the foliar bud, the succeeding scales (inner) show distinct characteristics. Those of the floral shoot (bud) are slightly broader especially those on the dorsal side of the beak-like formation. They are tough, rigid, triangular, and quite vaginate (Plate 4, figs. 1–17a) while those of the foliar shoots are usually slightly ovate or ovate-deltoid (Plate 3, figs. 2–16) and less tough.

It may be mentioned that on both shoot buds, the inner scales emerge only after growth has started for some time (Plate 2, figs. 2–3 and 5–6)). Also, in both cases the laminar primordia slightly decrease towards the inside (that is, longer on the outer scales and shorter for the inner scales) until the transition scales are reached (Plates 3 and 4, figs. 2–13), the latter having relatively longer ones. When the foliage leaves are reached (Plate 5, figs. 18–47), the sheaths are much reduced or are no longer noticeable. These structures become the true leaves upon further development.

Observations on many dissected buds have shown in many cases that floral shoot bud inner scales are quite similar to those of the foliar shoot bud, the decrease of the foliar primordia (protuberances) being irregular.

The flower or rather flower cluster primordia arise from the 5th or the 6th scale at its axil (Plate 2, fig. 8) and continuously up to and in the arrested foliage leaves (Plate 2, fig. 9). These inner scales and the abortive leaves become bracts subtending the lateral branches of the inflorescence or flower panicle. Both scales and leaves may fall off upon further development of the whole inflorescence. In the foliar shoot bud there are no outgrowths at the axils of the scales as borne out by observations, axillary buds being found only emanating at the axils of the true leaves (Plate 3, fig. 1).

Microscopical.—Plate 6, figs. 1 and 4 show median longitudinal sections of buds before smudging. Figure 1 (from trees 8, 9, and 10), figure 2 (from trees 2, 4, and 6), and figure 3 (from trees 3, 5, and 7) were taken on November 10–28, 1933 at Novaliches, Rizal. During the latter part of December the samples of buds taken appeared as in figure 4 (dormant stage). Note that up to this stage there is no way of telling whether the bud is to bear flower or not. Such a bud is potentially a leaf or a flower bud. This corroborates the findings of Lazenby(17) and Goff(10)(11)(12) who, in their studies on buds of apple, pear, plum, and other fruit trees found that during the early part of the growing season the structures and development of potential blossom and potential leaf buds are similar. The apical meristem is quite small and narrow although raised.

Finding that in 1933–1934 very few buds flowered, especially those of the selected trees at Novaliches and Central Experiment Station, smudging was resorted to during the 1934–1935 flowering season for observation, as soon as the twigs and leaves bearing the buds were well matured. The result is shown in Table 1. Table 2 shows the observation obtained in 1937.

TABLE 1.—*Period of bud differentiation as noted in 1934.*

Tree number	Date smudging begun	Differentiation first noted (microscopic)	First appearance of flower formation (naked eye observation)	Complete differentiation (microscopic)
1	Nov. 3, 1934	Nov. 18, 1934	End of November, 1934	Dec. 1–3, 1934.
2	Nov. 3, 1934	Nov. 8, 1934	End of November, 1934	Dec. 1, 1934.
3	Nov. 3, 1934	Nov. 8, 1934	End of November 1, 1934	Dec. 1, 1934.
4	Dec. 10, 1934	Dec. 15, 1934	First week of January, 1935	Jan. 7, 1935.[a]
5	Dec. 10, 1934	Dec. 19, 1934	First week of January, 1935	Jan. 7, 1935.[a]

[a] Buds attacked with fungus before complete differentiation was attained.

TABLE 2.—*Period of bud differentiation as noted in 1937.*

Tree number	Date smudging begun	Differentiation first noted (microscopic)	First appearance of flower formation (naked eye observation)	Complete differentiation (microscopic)
1	Oct. 27, 1937	Nov. 1, 1937	Second week of November, 1937	Nov. 15, 1937.[b]
2	Oct. 27, 1937	Nov. 5, 1937	End of 2nd week of November, 1937.[a]	
3	Oct. 27, 1937	Nov. 2, 1937	End of 2nd week of November, 1937.[a]	
4	Oct. 27, 1937	Nov. 10, 1937	Second week of November, 1937	Nov. 20, 1937.[b]

[a] Destroyed by the typhoon of November 11, 1937.
[b] Partly damaged by the typhoon of November 11, 1937.

It may be seen from the preceding tables that the range in smudging is from 6 to 17 days before any differentiation is noted (microscopically) and about 2 to 3 weeks before one could see with the naked eye the profuse formation of flower panicles. In 1934 the profuse appearance of flowers occurred in November for those smudged on November 3, while in 1937 the appearance was during the second week of November, the smudging having been done on October 27 as the trees were then ready and the weather favored the operation.

The dormant buds, based upon numerous dissections, whether they be examined any time between May and November, are composed of 28 to 36 pieces or parts, the outer 7 to 9 being scales followed by 1 to 3 transition scales which in turn are followed (towards the inside) by 20 to 24 foliage leaf primordia. With growth activity, whether the bud is smudged or not, tissues that appear as thickening (Plate 6, fig. 8) and later as protuberances (Plate 6, figs. 10–11) at first arise at the axils of from the fifth scale to the foliage leaves. Later, they become "club-like" in appearance. These are the flower cluster primordia (Plate 7, figs. 1–8). At this stage the inner scales (including the transition scales) as well as the foliage leaves serving as primary bracts have already expanded. When the floral shoot develops further these scales and bracts progressively fall off from the outer to the inner portions. This is also true of the scales of the foliar shoot, they being without leaves that serve as bracts but the foliage leaf primordia become normal leaves upon development.

The first indication of bud differentiation is the enlargement as well as the broadening of the axil in the region of the crown (cr.). At the same time there occurs an increase in size and greater elevation of the apical meristem (am) or growing point (Plate 6, fig. 5). For the purpose of this write-up let this be

called *Stage I.* Later, growth thickening appears at the axil of the fifth scale and so on in the case of the floral bud. This growth occurs on the 6th to the 10th and sometimes on the 17th day of smudging. *Stage II.* (Tables 1 and 2). For relatively younger buds the range is greater being about 11 to 17 days or possibly, even more.

An examination of sections shows that from 12 to 18 days and sometimes after 22 days, the apex slightly flattens preparatory to the formation of the terminal flower cluster primordium. By this time the first axillary flower cluster primordia begin to differentiate further showing more elevated protuberances (Plate 6, figs. 10–11). *Stage III.*

After 19 to 28 days of smudging, there appears in the terminal flower cluster primordium a sepal-like structure which may be further lateral flower cluster (Plate 7, fig. 8). Incidentally the first axillary flower cluster primordia show the formation of the branching of the panicles, with the first flower seeming to begin to differentiate (Plate 7, figs. 3, 4, 7, 8). *Stage IV.* This procedure of development is continued in each cluster, the lowest clusters always being more mature than the upper.

It may be mentioned that incident to this study, the development of flowers was observed. It shows that the floral parts develop in succession, viz., calyx, corolla, stamens, pistil, and finally the ovules. The findings of Juliano and Cuevas(15) on the Pico variety are, therefore, corroborated.

DISCUSSION

A study on bud differentiation in mango trees as well as on signs of pre-floral (at dormancy) formation is of great importance not only for scientific reason but also for practical and economic purposes. Smudging expenses to force mango trees to flower are often high; sometimes beyond the means of the grower. The present article endeavors to establish the differences between floral and foliar buds. It also tries to establish pre-floral characteristics that would enable one to determine which tree would bear profuse flowers with the least smudging even basing one's judgment only on the characteristics of the dormant buds.

External and internal changes in buds from dormancy up to the formation of flowers have been noted. Likewise the lapse of time or period in which flowers are formed in smudged and in unsmudged trees were recorded.

Studies on pre-floral characteristics have already been the subject of various investigations. For instance Goff(10)(11) considered the slight irregularities in the growing point or crown of buds as first evidence of differentiation while Drinkard(6) considered corrugations of the crown of the bud as the first morphological evidence that a differentiation into flower buds had taken place. Likewise, Kraus(16) considers the thickening of the flower axil as the first observable indications of the flower and Bradford(4) working on apple states that the first evidence of fruit bud formation is the rapid elevation of the crown into a narrow conical form, rounded at the apex, with the fibrovascular connections and pith areas advancing concurrently. Tufts and Morrow(18) working on almond, apple, apricot, cherry, peach, pear, and plum maintain that the definite broadening and thickening of the axils of buds are evidences of first differentiation in floral parts. They state that the formation of protuberances which eventually become the calyx, corolla, stamens, and pistil follows immediately.

Taking up the present work, it is apparent that prior to smudging, or at the dormant stage of the buds, no pre-floral characteristics that would show whether a tree is going to have profuse flowering or not, have so far been observed. For instance in 1933 the trees in Novaliches (without smudging) did not develop many flowers even up to February, 1934. Instead of flowers, leafy shoots were in more instances formed. Although it has been observed that buds from twigs with leaves that are light copper colored, mature, brittle, and leathery need a shorter period of smudging before flowers are developed, yet, one cannot be sure that such buds would, in the majority of cases, yield floral shoots especially when no smudging is done. This of course brings out the necessity of smudging. Hence such smudging was carried out in the latter studies.

The first external manifestation of the activity of dormant buds (with or without smudging) is the gradual loosening of the scales and the corresponding elongation or growth of the inner scales. This is clearly manifested by a well defined greenish area which was once covered by the several outermost scales. Such growth is shown after 6 to 17 days of smudging. For similar buds on unsmudged trees taken as subject of studies with the smudged ones none of such activities were observed within one and sometimes even within one and one-half months.

Observations show that even in buds of similar stage of dormancy, such growth or activities do not occur at the same period. Some manifest the signs after 6 days, others after 7 days, etc. These observations point to the obviousness of smudging operations.

Externally, it has been observed that buds which are to form flowers, show greater radial thickening due possibly to the growth of protuberances (flower cluster primordia) at the axils of the inner scales, beginning with the fifth scale, and the foliage leaves. As clearly noted from dissections (Plate 2, fig. 7) and from microscopic examination (Plate 7, figs. 3–8), such growth as fig. 5 of Plate 2 for instance is shown only as a result of the activities at the axils of both the scales (Plate 2, fig. 8) and foliage leaves (Plate 2, fig. 9). Moreover, buds that give forth inflorescences exhibit patently a "beak-like" appearance due to greater growth of scales and flower (cluster) primordia on one side (Plate 2, figs. 2, 5, 6, 7).

The results obtained from several trees at the Central Experiment Station at Singalong show that whenever such "beak-like" appearances (Plate 2, figs. 5–6) are seen in most buds, smudging is no longer necessary as the flowers must have had undergone differentiation already by then. It is important to know this characteristic as stopping smudging at this stage would result in considerably reduced expenses. Such formation (beak-like) persists for sometime even after the foliage leaves serving as bracts are fully developed (Plate 2, fig. 10). These scales and foliage leaves fall off as further growth and development of the flowers ensue.

At this juncture the question, can such appearance (beak-like) be exhibited without smudging arises? A systematic and thorough observation reveals these facts to be apparent: (1) that early flowering of mango could be enhanced by smudging, (2) that profuse flowering is made possible only through such operation, (3) that some trees may also flower even without smudging, although not as profusely as when they are smudged. The floral shoots that arise on unsmudged trees show this trait to be present in them. However, such floral shoots on unsmudged trees are not only relatively scanty but are late-comers. In the course of this work, for instance, while smudged trees in November bore profuse flowers in the same month those unsmudged in nearby places flowered in January–February and only few inflorescences were formed at that. Incident to this study

therefore one thing stands clear, and that is to force the trees to yield fruits early through smudging in order to command good prices.

From histological observations of buds, both from smudged and unsmudged trees, the writer is inclined to believe that changes from dormancy to the floral shoot bud stage occur as relatively sudden changes. With unsmudged trees for instance, no differentiation was observed from November to about December 20. Suddenly, examinations of buds 3 days thereafter showed some protuberances in some of them in appearance similar to those shown in Plate 6, fig. 9 (of the smudged trees).

Histological examinations of buds—both floral and foliar—show practically no differences in the few outermost scales, but certain differences are apparent in the inner scales. In the case of the foliar shoot bud, the inner scales exhibit certain changes in the shape of the sheaths as well as in the size of the laminar primordia. As already mentioned elsewhere, during the dormant stage of the bud the scales are more or less triangular. With the commencement of growth, however, the inner scales become ovatus-deltoídeus (ovate-deltoid) with the innermost two or three scales (excluding transition scales) slightly obovate. The laminar primordia become shorter and shorter up to the transition scales, where, again they become relatively longer. The sheaths of the transition scales elongate considerably with slight winged outgrowths as beginnings of laminar primordia at their adaxial sides. Such outgrowths are not so apparent unless the sheaths are well spread and clearly examined. The successive structures correspondingly show an increase in laminar development which will eventually result in distinct young leaves.

In the case of the floral shoot, dissections and examinations of numerous buds show that, although the scales are triangular to begin with, and with inner scales also ovate-deltoid or oblong upon further growth, because of greater development on one side than on the other (forming "beak-like" appearance of the bud), the increase in size of the sheaths is irregular as found by dissection in succession of the scales (Plate 4, figs. 4–16). The shapes are also quite irregular. Some sheaths are almost rounded (Plate 4, fig. 13), others quite obovate (Plate 4, fig. 16). The transition scales are generally relatively longer and broader than the foliar and with curvature tipping at one side (Plate 4, figs. 15a and 17a) due to uneven development of the bud. The

cause of such an unevenness has not been included in this study. Although not always, the inner scales do not show very distinctly the laminar formation. They serve as primary bracts that subtend the lateral branches of the floral cluster (Plate 2, fig. 8 and Plate 7, fig. 5).

Through microscopic examination it has been noted that after 6 to 17 days of smudging (on smudged trees), activities are shown both in the lateral and the apical meristem. In case of foliar shoots, such activities become manifest only at the apical meristem.

SUMMARY

1. This paper gives the results of studies on bud differentiation in smudged and unsmudged Carabao mango trees at Novaliches, Lamao, and Singalong.

2. Results seem to establish no definite pre-floral characteristics to enable one to predict whether or not dormant buds would develop either into flowers or leaves.

3. Although observations did not exactly establish any definite characteristic it was observed that buds from stems with leaves that were light copper, mature, brittle, and leathery required comparatively shorter period of smudging than those from slightly younger stems before flowers were developed.

4. Smudging apparently shortens the dormancy of buds. It took only 6 to 17 days after smudging to show signs of differentiation.

5. Externally, the first manifestation of the activity of the bud whether smudged or not is the loosening of the scales and the elongation and slight broadening of the inner scales showing marked green color of the inner scales once covered by the few outermost ones.

6. The external sign of a bud (already in an advanced stage) about to form floral shoot is its greater radial thickening, perhaps as a result of the growth of flower cluster primordia at the axils of the inner scales and the foliage leaves. With further development the floral shoot exhibits a patently "beak-like" appearance due to greater growth on one side of the bud. When such a stage is reached it is quite safe to stop further smudging as the flowers by then have already differentiated. This greatly lessens the cost of smudging.

7. Microscopic examination of buds shows that growth activity on apical meristems, in the axils of the scales (from the 5th inwards) and in the foliage leaves occur in 6 to 17 days of con-

tinuous smudging. The period is shorter for the older dormant buds. Buds from relatively young twigs require a longer period of smudging before some flowers develop.

8. The inner scales of foliar shoots are triangular at first, but become ovate-deltoid when activated with laminar primordia, decreasing in size up to the transition scales when again such protuberances (laminar primordia) become very apparent, while the transition scales become long and narrow.

9. The inner scales of the floral shoot are irregular in sizes due to the greater growth on one side (forming beak-like appearance), those on the "dorsal" side being bigger than those on the "ventral" thus giving the beak-like appearance of the bud. As a whole the scales are relatively bigger and broader than those of the foliar shoots. The shape is also broadly ovate-deltoid, in some cases almost rounded.

ACKNOWLEDGMENT

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LITERATURE CITED

1. Alcala, P. E. and A. San Pedro. Bud differentiation on smudged mango trees. Philippine Agriculturist 24 (1935) 27–48, pl. 4, fig. 69.
2. Ball, E. The time of differentiation and the subsequent development of the blossom bud of the plum. Journ. Pom. and Hort. Sc. 6 (1927) 3.
3. Barnard, C. and F. M. Read. Studies of growth and fruit bud formation. Jour. of the Dept. of Agri., Victoria, Australia 31 (1933) 37–52, pl. 4, fig. 4.
4. Bradford, F. C. Fruit bud development of the apple. Oregon Agrl. College Expt. Sta. Bull. 129 (1915) 1–16, pl. 6.
5. Chamberlain, C. J. Methods in Plant Histology (1915). xi + 314 p., 107 fig. Chicago: The University of Chicago Press.
6. Drinkard, A. W. Fruit-bud formation and development. Virginia Agrl. Expt. Sta. Report (1910) 159–205, figs. 63–168.
7. ..... Annual report. Bureau Agr. (1924) 79, 127. (Abstracts of 1923 and 1924 Annual Reports of the Lamao Horticultural Station).
8. Galang, F. G. and J. A. Agati. A progress report on the influence of heat and smoke on the development of mango buds. Phil. Jour. Agr. 7 (1936) 245–261, fig. 3.
9. Galang, F. G. and J. A. Agati. Further study on the influence of heat and carbon dioxide on the development of Carabao mango buds. Phil. Jour. Agr. 8 (1937) 379–388.

10. Goff, E. S. The origin and early development of the flowers in the cherry, plum, apple and pear. Sixteenth Annual Report of the Wisconsin Agrl. Expt. Station (1899) 289–303, figs. 55–77.
11. Goff, E. S. Investigation of flower buds. Seventeenth Annual Report of the Wisconsin Agrl. Expt. Station (1900) 266–285, fig. 40–72.
12. ..... The origin of the development of fruit buds. Twentieth Annual Report of the Wisconsin Agrl. Expt. Sta. (1903) 360–362.
13. Gonzalez, L. G. The smudging of mango trees and its effects. Philippine Agriculturist 12 (1923) 15–28.
14. ..... Influence of smudging on the respiration and catalase activity of the mango (*Mangifera indica*, Linn.). Philippine Agriculturist 21 (1932) 533–540, fig. 1.
15. Juliano, J. B. and L. C. Cuevas. Floral morphology of the mango (*Mangifera indica*, Linn.), with special reference to the Pico variety from the Philippines. Philippine Agriculturist 21 (1932) 449–467, pl. 15.
16. Kraus, E. J. Gross morphology of the apple. Oregon Sta. Research Bulletin 1 (1913) 1–12, pl. 7.
17. Lazenby, W. R. The development of the buds in some of our common orchard fruits. Proceedings of the American Pomological Society (1899) 40.
18. Tufts, W. P. and E. B. Morrow. Bud differentiation in deciduous fruits. Hilgardia, Cal. Agrl. Expt. Station 1 (1925) 1–14, pl. 11.
19. Wester, P. J. The mango. Bur. Agr. Bull. 18 (1920) 1–70, pl. 17, fig. 9.

ILLUSTRATIONS

Plate 1

Fig. 1. Side view of a typical dormant terminal bud. (A) base of petiole. (B) Scale. (×8)

2. Dorsal view of an outer scale of a terminal bud. (×8)
3. Ventral view of an outer scale of a terminal bud. (×8)
4. Dorsal view of a transition scale of a terminal bud. (×8)
5. Ventral view of a transition scale of a terminal bud. (×8)
6. Showing the cone-like structure of the foliar primordia after the removal of the scales. (×10)
7. Showing the slightly elevated tissue after the removal of scales and foliar primordia from a dormant bud. (×14)
8. Dorsal view of a foliar primordium that later becomes an abortive true leaf and serves as a primary bract of a flower panicle, or a leaf in case of a foliar shoot bud. (×14)
9. Ventral view of (8) showing the numerous hairs. (×14)
10. Showing the structure and form of a multicellular and a unicellular hairs of the foliar primordium. (H. P.)
11. Dorsal view of a typical dormant axillary bud. (A) base of petiole. (S) Scale. (×8)
12. Showing the structure and form of the hairs on foliar primordia. (H. P.)
13. Dorsal view of an outer scale of an axillary bud. (×8)
14. Ventral view of an outer scale of an axillary bud. (×8)
15. Showing the slightly elevated tissues after scales and foliar primordia are removed. Note the slightly compressed condition. (×14)
16. Dorsal view of a transition leaf of axillary bud. (×8)
17. Ventral view of a transition leaf of an axillary bud. (×8)
18. Showing the cone-like formation of the foliar primordia of an axillary bud. Note the shorter length of those at the left side (due to the slight compressed condition) as normally growing at the axil of the leaf. (×10)

19–20. Dorsal and ventral views of a foliar primordium. This organ becomes the abortive true leaf of a flower bud, or a well-developed normal leaf of a foliar bud. (×10)

Plate 2

Fig. 1. A diagram showing the organography of a dormant terminal bud. (S) scale, (TS) transition scale, (F) foliar primordium, (am) apical meristem. (×8)

2. An advanced stage of a terminal floral bud. (×6)
3. An advanced stage of a foliar shoot bud. Note its leaner appearance and the tendency to have a rather straight growth. (×3)
4. A terminal bud getting to be active after 7 days of smudging. (P) base of petiole, (S) scale. (×8)

FIG. 5. A terminal bud after 14 days of smudging showing plumpness and the tendency to have a "beak-like" formation. These are signs that the bud is a flower bud. (×6)

6. A terminal bud (more advanced than 5) showing the pronounced beak-like formation of a floral shoot bud. (×2)

7. A floral shoot bud after the scales and foliar primordia are removed. Note the flower cluster primordia (FP). (×14)

8. Ventral view of an inner scale bearing a flower primordium. (S) scale, (FP) flower cluster primordium. (×2)

9. Ventral view of a true leaf bearing a flower cluster primordium at its base. (FL) foliage leaf, (FP) flower cluster primordium. (×2)

10. An advanced floral shoot with scales fallen and with leaves that are well differentiated but are of arrested growth and serving as primary bracts. These leaves sooner fall off also developing flowerets (F). (L) leaf. (×1)

PLATE 3

FIG. 1. A foliar shoot bud with scales all removed to show the lean appearance of stem. (×2.5)

2–13. Scales of a foliar shoot bud. Note the increasing sizes of scales towards the inside of the bud. Note further the decreasing sizes of the protuberances at tips (laminar primordia). (×2)

14–16. Transition scales of a foliar shoot bud. Note their narrowness and great elongation. Note further the laminar primordia. (×2)

PLATE 4

FIGS. 1–14. Scales of a terminal bud at a stage as of Plate 2, fig. 2. (×2)

15–17. Transition scales of the same terminal bud. (×2)

15a–17a. Transition scales of a typical terminal floral bud at full development as of a stage as that shown in Plate 2, fig. 2. (×2)

PLATE 5

FIGS. 18–47. Showing the beginning of the greater development of the primordia that become the true leaves but of abortive development; becoming primary bracts of flower panicles. Note the apparent alternation of sizes due to the greater development at one side of the floral shoot resulting in "beak–like" appearance. Note also the arrested development of the sheaths. (×2)

PLATE 6

Median longitudinal sections

FIG. 1. A very young bud as appearing on number 10 from shoots that appeared at the end of October. (cr) crown of bud, (S) scale. (×45)

2. Showing the growth of buds as in Fig. 1 after 6 days. Note the primordia (p) arising from the apical meristem. (×45)

3. Showing further growth of the bud as of Fig. 2 after 12 days. (×45)

FIG. 4. A bud at about the incipient (dormant) stage before smudging. (×45)

5. A bud after 6 days of smudging. Note broadening of apical meristem (am). (×45)

6. Showing the beginning of the activity of the tissues at the axils (a) after 7 to 16 days of smudging. (×45)

7. Further activity at the axils. Note greater development of the vascular bundle (vb). (×45)

8–11. Further successive growth of the primordia at the axils. Figs. 10 and 11 show the differentiation of the floral buds as shown by the growth of the primordia at both the axils of the scales (S) and leaf primordia (LP). (×45)

PLATE 7

Median longitudinal sections

FIGS. 1–2. Further development of flower cluster primordia at axils of both scales and foliage leaves. (×45)

3–5. Floral shoot bud development (originating from axillary buds). (S) scales, (FP) flower cluster primordium, (LP) leaf primordium after 19–28 days of smudging. Note formation similar to terminal buds. (×45)

6–8. Floral shoot bud development (originating from apical buds). (FP) flower primordium, (S) scales, (LP) leaf primordium. Note formation of sepal-like structure (se) 14–25 days after smudging, which may become first flowerets. (×45)

9. Showing buds that have not changed much even after 4 weeks of smudging. Note however that there seem to be formation of bud primordia at axils (see thickening) of the foliage leaves. They may eventually give rise to axillary buds. (×45)

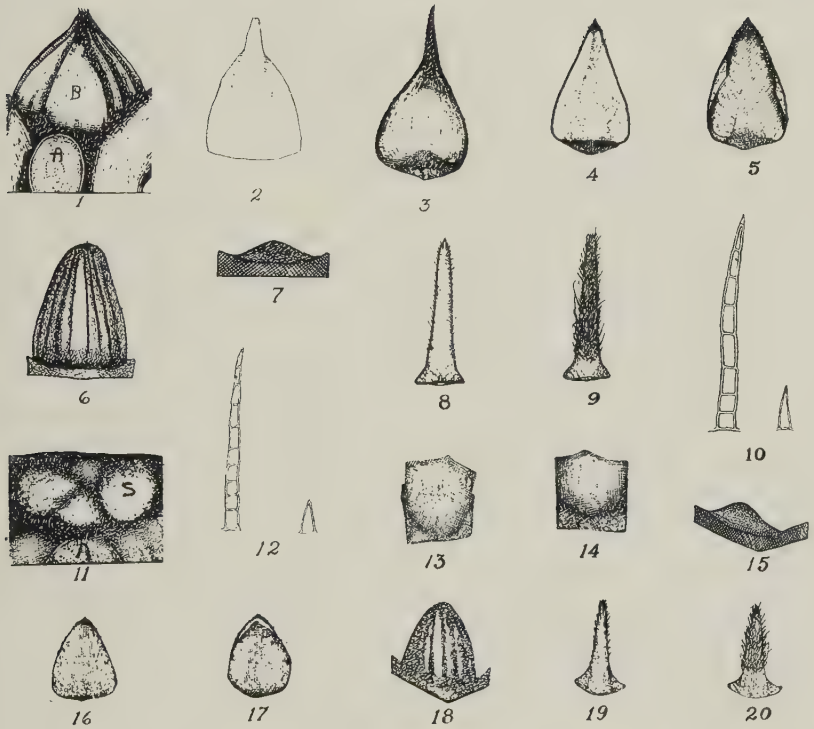

PLATE 1.

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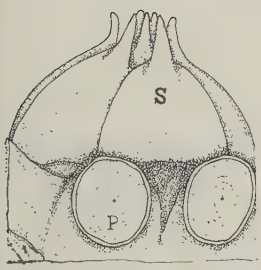

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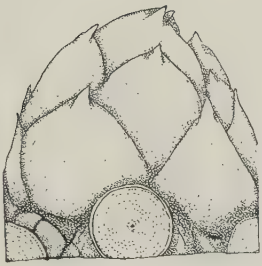

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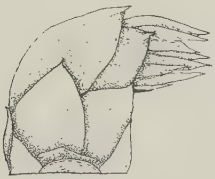

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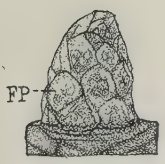

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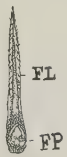

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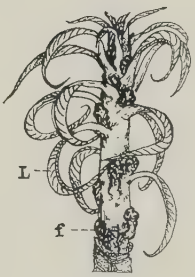

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PLATE 2.

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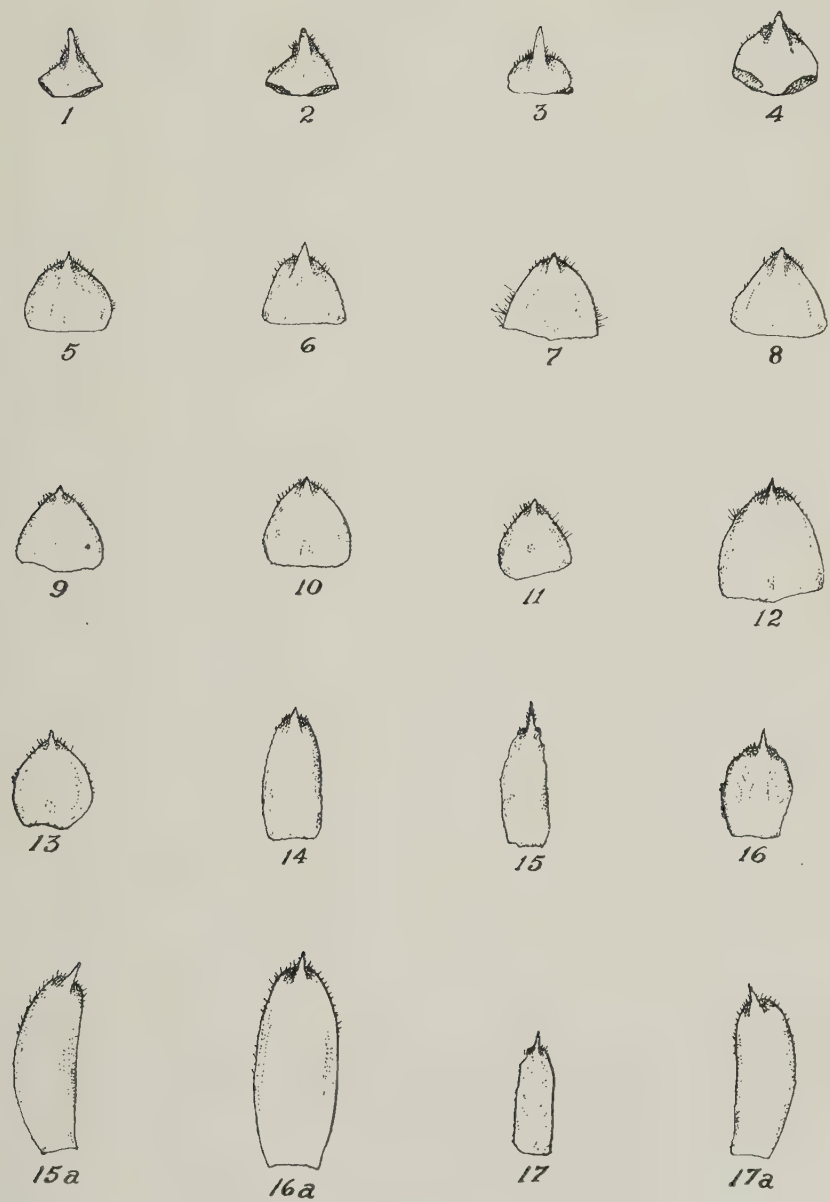
PLATE 3.



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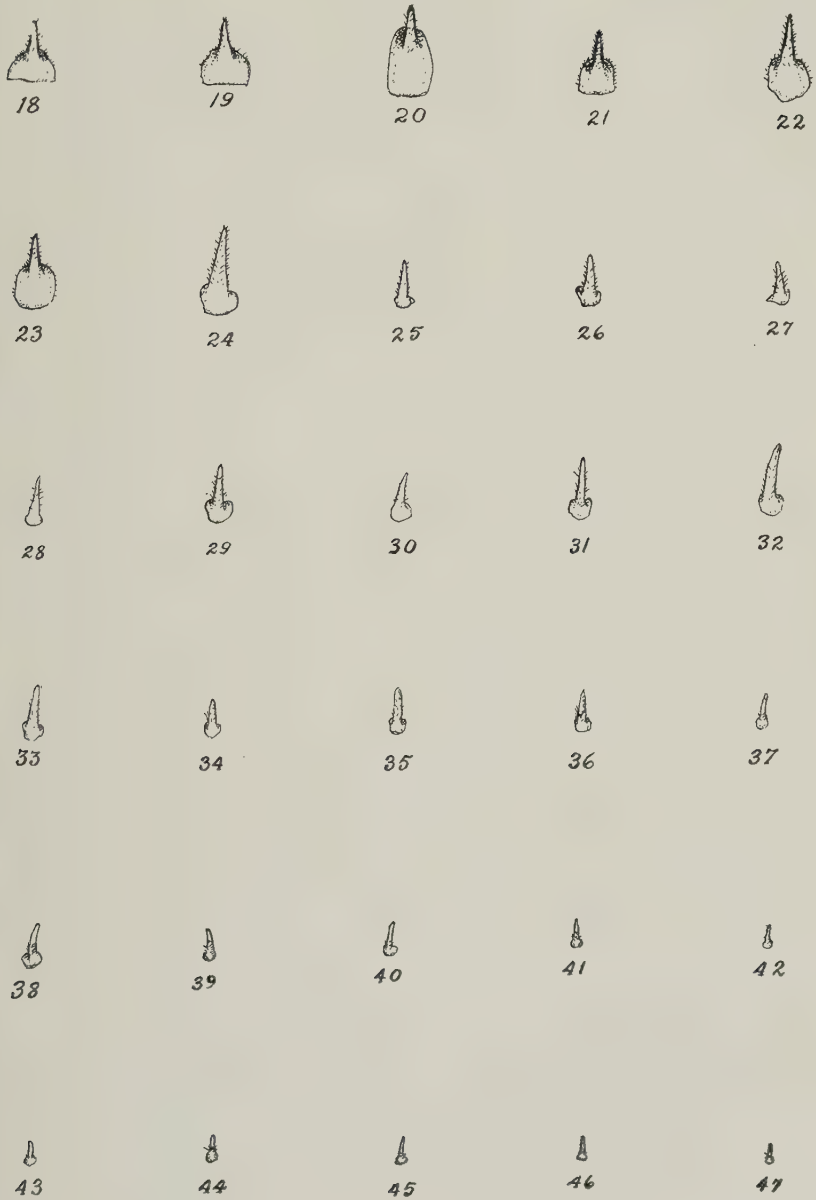
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PLATE 5.

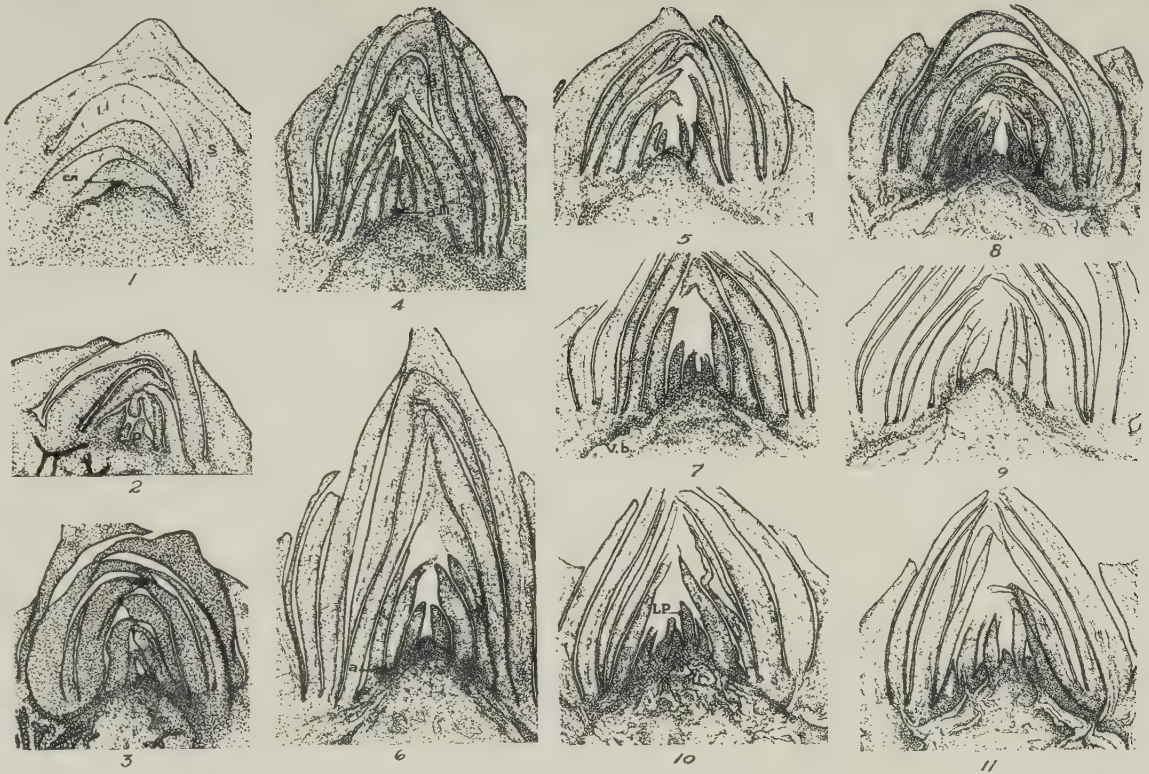

PLATE 6.

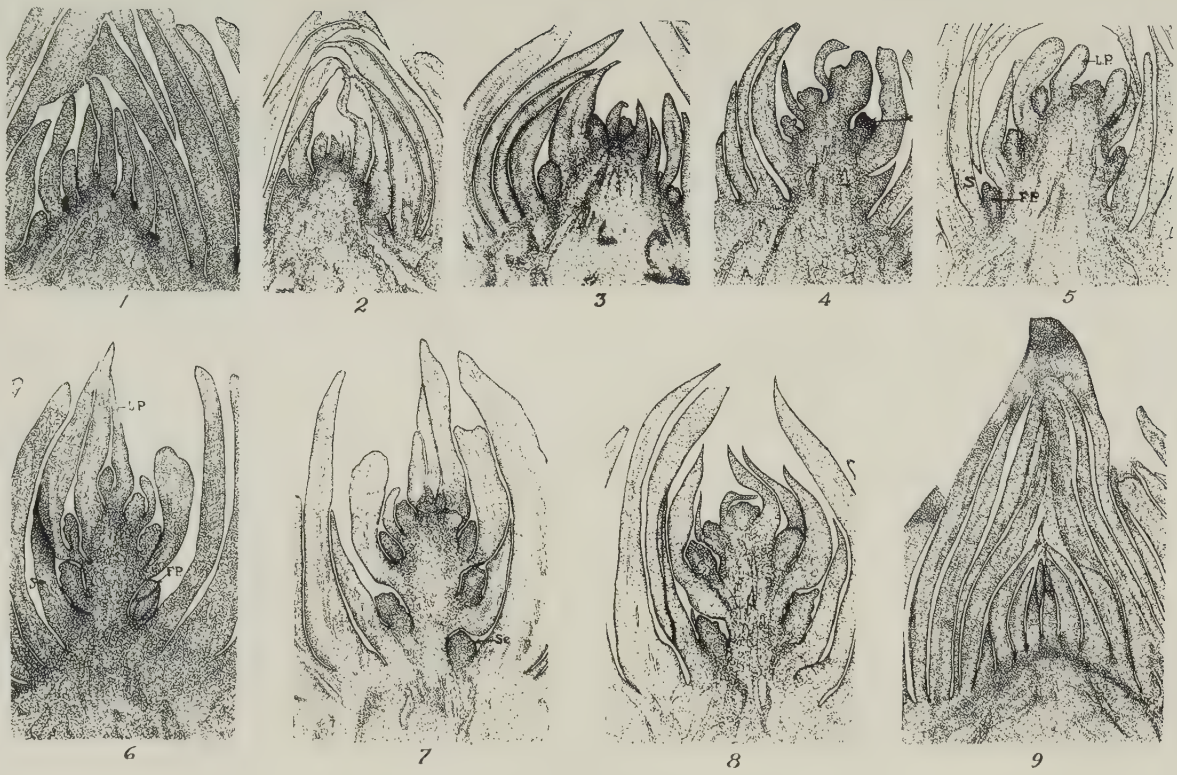

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PLATE 7.

THE RICE CADANG-CADANG IN ALBAY PROVINCE: I. ITS PROBABLE CAUSE

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Of the Bureau of Plant Industry, Manila

SEVEN PLATES

The so-called rice *cadang-cadang* in Albay first elicited the attention of the Bureau in the early part of 1935, through Hon. E. Kare, then Assemblyman for Albay who reported the malady to the Bureau of Plant Industry. Mr. Pedro L. Sison, assistant agronomist, being in Albay at that time was commissioned to investigate the malady. After surveying a total of about 32 hectares of affected fields in the towns of Camalig, Guinobatan, Ligao, Oas, Polangui and Libon, Mr. Sison entertained the suspicion that *cadang-cadang* might be due to two causes, to wit, damaged roots due to certain fungus attack and starvation caused by depleted condition of the soil.

Since the initial outbreak of the malady, apprehension has been rife among farmers of Albay who fear the possibility of its spreading throughout the entire province. Every now and then letters keep pouring into the Bureau inquiring of the proper methods of control. In response to the said requests, a party composed of Messrs. Gaudencio M. Reyes, Rufino Isidro, and Julian A. Agati, all of the Bureau of Plant Industry was sent to Albay in November, 1935 to conduct an extensive survey and thorough study of the malady. Among other things, the junior author found the following:[1]

1. *Symptoms of rice cadang-cadang.*—The plants affected by *cadang-cadang* manifest a decided yellowing of the leaves and are generally stunted in growth. The older leaves become light orange or yellow and only the inner younger leaves remain green. The dwarfing of the plants is probably due to the persistent yellowing and eventual drying of the leaves. The yellowing starts from the outer leaves and works inward to the inner young leaves. The roots of the plants are mostly brown; only those extending horizontally from the base of the plants are white and turgid.

[1] A manuscript, entitled "Preliminary Studies on the So-Called Rice "Cadang-Cadang" in the Bicol Provinces" is on file in the Bureau of Plant Industry, Manila.

2. *Extent and distribution of the malady.*—*Cadang-cadang* was observed in patches throughout the regions west of the Mayon Volcano, extending from Polangui to Camalig in the south. The malady was present in both irrigated and unirrigated paddies where the surface soil is generally shallow and sandy, measuring about 4 to 5 inches deep. The sub-soil is predominantly sandy to gravelly.

3. *Seasonal occurrence of cadang-cadang.*—*Cadang-cadang* appears in July or August, or about a month or so after transplanting which is usually done in May or June. The effects of the malady on Baranay, the variety of rice commonly planted in Albay, become evident about July or August or a month or so after transplanting.

4. *Actual conditions of the rice paddies.*—The rice paddies in Albay are generally weedy. However, *cadang-cadang* appears irrespective of whether the paddy is weedy or not. In the weedy paddies, eight different kinds of weeds were identified by Mr. L. Karganilla of the Bureau of Science, though only two are common and persistent. The first is called *San Jacinto* (*Ischaemum rugosum* Salisb. var. *distachyum*) and the second is the *balangot* (*Cyperus pilosus* Vahl.). Since these weeds are promiscuous growers they often choke out the rice seedlings in the paddies.

5. *Results of soil analysis.*—To get a clear idea of the nature and composition of the soil where *cadang-cadang* thrives, soil samples were analyzed.

The results of the analysis are shown in Table 1.

TABLE 1.—*Analysis of the constituents of soil taken from Polangui, Libon, Oas and Camalig, Albay* [a]

Constituents	Normal soil	Cadang-cadang soil
	Per cent	*Per cent*
Nitrogen—total	0.266	.175
P_2O_5—total	.306	.231
Available [b]	.052	.052
K_2O—total	.428	.426
Available	.011	.010
Ca_2O—total	5.92	7.47
Available	.72	.33
Fe_2O_3—total	9.16	9.64
Available	0.68	0.44
Al_2O_3—total	20.56	18.50
Available	0.78	.91
Mg_2O—total	2.83	3.07
Available	.082	.082
SO^3—total	.381	.550
Available	.044	.033
Alkalinity as $CaCo_3$—total	0.815	.836

Table 1 shows very clearly the presence in very little amounts of the principal plant food elements usually deficient in the soil, namely, nitrogen, phosphorous and potassium.

[a] Analyzed by Mr. Rufino Isidro and reported to the Bureau of Plant Industry.

[b] Available determination = Soluble in 1 per cent acetic acid and all other figures are on water-free basis.

6. *Results of pot culture studies summarized.*[c]—The addition of sulphate of ammonia, double superphosphate of lime and sulphate of potash separately to each canful of *cadang-cadang* and normal soils planted to rice plants at the rate of 200 kg. per hectare did not only improve the general stand and growth of the plants but also augmented the yield. The trend of results obtained seems to point to the probability that the rice *cadang-cadang* complex in the Bicol region might be linked with the deficiencies in available soil nutrients in the soil like phosphorous, nitrogen and to a slight extent, potash (Plate 1).

DEMAND FOR FURTHER STUDY

The appearance of rice *cadang-cadang* to an alarming extent in the Bicol region in the year 1937 made the farmers reluctant to grow rice in their fields the following season. This attitude of the farmers prompted the Director of Plant Industry to appoint a committee in December, 1937 to extend the study thus far conducted by the junior author that remedies or control measures may be devised. The committee is composed of Dr. Fernando de Peralta, chairman, Messrs. J. A. Agati, V. Borja and R. Isidro, members.

PLAN OF STUDY

Based on the results of soil analysis submitted by Mr. Rufino Isidro and the results of pot cultures summarized in this paper, the study of rice *cadang-cadang* was undertaken in the light of the following questions:

1. Does the soil sample known to cause rice *cadang-cadang* in the Bicol provinces produce the symptom of *cadang-cadang* on rice when placed in petroleum cans watered regularly with Manila water supplied by the Manila Metropolitan Water District?

2. Is *cadang-cadang* due to the activity of soil fauna connected with plant food consumption or due to "locked" up condition of plant food nutrients present in the soil?

3. Is *cadang-cadang* not the result of food deficiency in the soil and, if it is, which of the three principal food elements, namely, nitrogen, phosphorous and potassium is the limiting factor? The answers to these questions were worked out simultaneously and are being presented in this paper as Experiments 1, 2 and 3. The experiments were conducted in the premises of the laboratory of the Tobacco Research Section from December, 1937 to August, 1938.

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[c] The results are taken from an unpublished manuscript now on file in the Bureau of Plant Industry, Manila. The soil used in the studies was obtained from Albay province. Baranay which is commonly planted there was used in the experiment.

MATERIALS, METHOD AND RESULTS

SOIL

Sufficient soil samples obtained at random from a *cadang-cadang* infested field and from adjacent non-infested places to fill no less than thirty petroleum cans each were taken from Mayao, Oas, Albay in December, 1937. The composite samples were brought to Manila for laboratory study. The samples were clay-loam, dark gray and showed all the appearances of a fertile soil. They were placed separately in the greenhouse to dry. Each soil sample was mixed thoroughly with the use of spade and fork. For convenience, the *cadang-cadang* infested soil and the normal soil (*cadang-cadang* free) are designated in this report as C–soil and N–soil, respectively.

Experiment 1.—Five empty petroleum cans were filled to about 15 centimeters from the rim with C–soil. Enough tap water was poured into the container to bring the moisture saturation of the soil to about 70 per cent. Seeds of the variety of rice Baranay were sown and spaced 15 cm. apart in the can. Four hills of five seeds to a hill were planted in every container. The cultures were then placed outside of the laboratory in order to receive the full impact of the environment. The cans were set in a row and spaced 15 cm. apart. When the seeds had fairly germinated and attained a height of about 10 cm., the number of seedlings to a hill was reduced to two. Only uniform seedlings were left. After the second week, the number was finally reduced to one to the hill so that in every culture can there were four plants only. From the seedling to the fruiting stage at least a depth of about five centimeters of water was maintained in the can. Watering was done as often as necessary with water taken directly from the faucet.

Using the N–soil as media, another set of cultures was prepared. The same number of cultures and treatment administered were utilized. The set was then placed alongside the C–soil cultures outside of the laboratory.

Experiment 2.—Experiment 2 was divided into two parts. The first part was conducted as follows:

(1) From the same soil stock used in Experiment 1, enough C–soil was taken and heated continuously to about 70° C. during a period of eight hours and thereafter heated for the same length of time and degree of temperature every three days for a period of six days. The three petroleum cans prepared for the purpose were then filled with the heated soil up to about 10 cm. from the rim. Other three petroleum cans were also filled with the same kind of soil (C–soil) but were not heated. Both sets (the heated and the unheated C–soil) were planted to rice and then treated as in Experiment 1. The operation was repeated except that the soil media employed was the N–soil.

(2) The second part of Experiment 2 was prepared as follows: Twelve petroleum cans prepared for the purpose were filled with soil as described in Table 2.

TABLE 2.—*Treatment of soil placed in petroleum cans for rice culture*

Culture number	Kind and treatment of soil in can	Source of water for watering
1, 2, 3	C-soil, unheated	Watered with aqueous soil extract of heated C-soil.
4, 5, 6	C-soil, heated [a]	Do.
7, 8, 9	N-soil, heated	Watered with aqueous soil extract of unheated C-soil.
10, 11, 12	N-soil, unheated	Do.

[a] The method of heating the soil used in this experiment was the same as that followed in the first part of Experiment 2.

After the cultures were prepared as described in Table 2, they were placed outside the laboratory. The treatments administered the cultures were the same as those described in Experiment 1.

Experiment 3.—C– and N–soils mixed separately with fertilizer mixtures as shown in Table 3 were put in 10 petroleum cans and planted to rice. The method and treatments given to the plants were exactly the same as those described in Experiment 1. The amount of each kind of fertilizer added to a canful of soil (based on surface area exposed) was computed at the rate of 150 kilograms per hectare. Other two cans each of C– and N–soils, without fertilizer, were also planted to rice. These cultures served as control.

TABLE 3.—*Amount of fertilizer mixture added to canfuls of C- and N-soils employed in experiment 3*

Fertilizer mixture	Number of culture	C–soil	N–soil
		Amount	Amount
		grams	*grams*
1. Sulphate of Ammonia	2	8.25	8.25
Sulphate of Potash		8.25	8.25
2. Sulphate of Ammonia	2	8.25	8.25
Double superphosphate		8.25	8.25
. Sulphate of Potash	2	8.25	8.25
Double superphosphate		8.25	8.25
4. Sulphate of Ammonia	2	8.25	8.25
Sulphate of Potash		8.25	8.25
Double superphosphate		8.25	8.25
5. Sulphate of Ammonia	2	8.25	8.25
Sulphate of Potash		8.25	8.25
Double superphosphate		8.25	8.25
Sulphate of Magnesia		8.25	8.25
6. Experiment 1	No fertilizer applied (control).		

The results of this experiment are presented in Tables 4, 5, 6, 7, and 8. The growth behavior of the rice plants under the condition described in Experiment 1 will be presented first. The effect of heating the media and of watering the plants with aqueous soil extract upon the rice plants will then be discussed. Finally, the beneficial effect of adding commercial fertilizers upon the growth and yield of the rice plant will be given.

DISCUSSION OF RESULTS

EFFECT OF SOIL MEDIA

Cadang-cadang symptoms.—The leaves of rice plants grown in the C-soil (*cadang-cadang* infested soil) were much lighter green than the leaves of those plants in the N-soil (normal soil). The symptom of rice *cadang-cadang* observed in the field in the Bicol provinces was exhibited by the plants grown in the C-soil, but only to a lesser degree. This is attributed to the fact that the latter had better cultural treatment than those actually planted in the field. The unavoidable presence of weeds in rice paddies robs rice plants of soil nutrients and water. Such condition was absent in the can cultures.

Growth and yield of rice plants compared.—The plants in the C-soil were inferior to those grown in the N-soil. In spite of the fact that the plants in the C-soil were a little bit taller than those in the N-soil on February 4 (Table 4), they (the plants in

C-soil) were shorter upon reaching maturity. The beginning of the better growth and development of the plants in the N-soil was noted when the plants were forty days old (Plate 2), and this growth behavior continued until the plants were harvested on June 9.

Based on the yield of 4 plants as shown in Table 4, the N-soil produced heavier weight of grains and straw. An average of 27.6 ± 1.25 grams of grains was obtained from 5 cultures of N-soil as against 20.4 ± 0.51 grams from the C-soil. In straw, the former produced 62.4 ± 1.46 grams as against 45 ± 2.27 grams of the latter. It is apparent, therefore, that the C-soil as regards grain production was only 74 per cent as good as the N-soil. As a straw producer the C-soil was 28 per cent poorer than the N-soil (Table 4).

EFFECT OF HEAT AND AQUEOUS SOIL EXTRACT

Luxuriant growth of rice in heated soil.—The symptom of rice *cadang-cadang* did not appear on the rice plants grown in heated C-soil. Instead they showed increased growth and yield of grains and straw (Table 5). The favorable effect of heating the soil upon the growth of the plant as indicated in Plate 3 was noted also. The leaves were green, broad and long and the yield in grains increased from 20.5 grams (when the C-soil was not heated) to as high as 92.6 ±1.19 when heated (Table 5). The same trend of results was also observed in the N-soil. It appears probable, therefore, that the heat treatment given to the C-soil as described in the first part of Experiment 2 has changed, modified or ushered in a condition whereby the nutritive substances in the soil became available to the rice plants. This result seems to corroborate the finding of Gustofson(1) who says that heating soil with steam increases the solubility of P_2O_5 and nitrogen compounds. Steemkamp(2) and Mortensm and Dudley(3) claim that drying generally increases the solubility of soluble constituents of the soil.

Aqueous soil extract of C-soil does not produce rice cadang-cadang.—As described in Experiment 2 under Table 2, the aqueous soil extract of unheated C-soil was administered continuously to the rice plants grown in the heated and unheated N-soils. The plants did not produce the symptoms of *cadang-cadang* (Plate 4). The plants grown in the heated N-soil had dark green, broad and long leaves. Although the growth of the plants in the unheated N-soil was not as vigorous as those in

TABLE 4.—*Growth and yield data of four rice plants grown in a petroleum can (3.5 × 3.5 cms.) with cadang-cadang infested and non-infested soil (normal soil)*

Culture designation	Culture number	Date of observation and criteria studied							Dry weight of grains	Dry weight of stalks	Presence or absence of cadang-cadang symptoms
		Feb. 4	Feb. 15	Feb. 25	March 7	June 9					
		Height	Height	Height	Height	Height	Number of bearing culms	Number of non-bearing culms			
		cms.	*cms.*	*cms.*	*cms.*				*gms.*	*gms.*	
C-soil (cadang-cadang soil)	1	23.7	40.2	50.1	52.7	125	10	1	20	40	Present.
	2	22.2	38.8	49.0	56.2	120	11	0	22	51	
	3	19.3	35.0	44.0	51.0	130	10	6	20	41	
	4	21.3	41.6	45.2	49.7	131	9	2	18	38	
	5	21.7	39.2	49.5	53.3	127	11	4	22	55	
Average		21.6	38.9	47.5	52·6	126	10.2	2.6	20.4±0.51	45 ±2.27	
N-Soil (normal soil)	1	19.7	39.3	50.5	59.7	122	11	8	22	57	Absent.
	2	22.0	38.8	49.0	58.8	141	12	3	32	70	
	3	23.2	46.1	63.5	70.5	135	14	1	28	61	
	4	22.9	45.7	60.7	70.0	134	13	0	26	59	
	5	26.8	47.7	63.7	72.5	125	15	1	30	65	
Average		22.9	43.5	57.5	66.3	131	13	2.6	27.6±1.25	62.4±1.46	

DESCRIPTION:

C–Soil—The symptom of rice cadang-cadang observed in the Bicol region appeared during the growth of the rice plants, but to a lesser degree.

M–Soil—The plants were darker green than those grown in the C-Soil. Growth was slow, but the plants were normal.

TABLE 5.—*Growth and yield data obtained from four rice plants grown in petroleum cans with cadang-cadang infested and non-infested soil (normal soil), both heated*

Kind and treatment of media	Culture number	Date of observation and criteria studied							Dry weight of grains	Dry weight of stalks	Presence or absence of cadang-cadang symptoms
		Feb. 4	Feb. 15	Feb. 25	March 7	June 9					
		Height	Height	Height	Height	Height	Number of bearing culms	Number of non-bearing culms			
		cms.	*cms.*	*cms.*	*cms.*	*cms.*			*gms.*	*gms.*	
Cadang-cadang soil, heated to 70° C. for 8 hours, three times at 3 days interval.	1	21.8	45.0	53.9	81.0	161	48	18	96	288	Absent.
	2	23.2	45.7	58.3	76.0	170	50	20	92	280	
	3	21.7	38.3	50.8	73.0	160	45	20	90	272	
Average		22.2	43.0	54.1	76.6	163.6	47.6	19.3	92.6±1.19	280 ±3.11	
Normal soil heated to 70° C. for 8 hours, three times at 3 days interval.	1	24.2	45.7	60.2	88.7	198	56	15	111	372	Absent.
	2	25.7	46.1	62.0	79.5	190	52	12	108	352	
	3	26.8	42.0	58.0	72.7	188	51	12	106	345	
Average		25.6	44.6	60.0	80.3	192.0	53.0	13	108.3±0.98	356.3±5.38	

NOTE.—For results of unheated C-Soils and N-Soils see Table 4.

the heated N-soil (Plate 4), yet the leaves were normal green. They yield obtained from the heated soil, however, was much more than that from the unheated N-soil. In the heated N-soil an average of 113 ± 0.93 grams of grain was obtained as against 28.3 ±0.81 grams in the unheated N-soil (Table 6). In the same manner, the heated C-soil watered continuously with aqueous soil extract of heated C-soil produced very luxuriant growth of rice similar to those in the heated N-soil but the unheated C-soil produced poor plants (Plate 5). Again the characteristic yellowing of the rice leaves (*cadang-cadang* symptoms) was observed. From the above facts it can be deduced that the factors causing rice *cadang-cadang* are not transmissible and therefore rice *cadang-cadang* is not due to living organisms but most likely due to the lack of soil fertility.

EFFECT OF FERTILIZERS ADDED TO SOIL MEDIA

Rice cadang-cadang symptom absent.—The addition of certain combinations of inorganic fertilizers to the C-soil did not only augment the yield of the rice plants grown therein but also prevented the appearance of *cadang-cadang* (Plate 6). *Cadang-cadang* appeared on the rice plants planted in the unfertilized C-soil. The plants were poor, stunted, with narrow chlorotic leaves. It appears, therefore, that the cause of rice *cadang-cadang* is due to lack of soil fertility necessary for the normal growth of rice. In the same manner, the addition of inorganic fertilizers to N-soil also improved tremendously the productive capacity of the N-soil as shown by the luxuriant growth of the rice plants (Plate 7). The unfertilized cultures, although the growth of the plants was not as luxuriant, attained normal growth. But even at that the N-soil and more so the C-soil imperatively demand the application of fertilizers.

Lack of nitrogen in the soil.—The result shows that the C-soil is deficient in nitrogen (Table 7). There were enough phosphorous and potassium. The deficiency in nitrogen in the C-soil caused the appearance of what the Bicolanos call rice *cadang-cadang* (yellowing of leaves). These statements are based on the fact that when the combination of sulphate of ammonia and sulphate of potash; sulphate of ammonia, sulphate of potash and double superphosphate were added to the soil separately the rice plants grown therein did not show the symptom of rice *cadang-cadang,* but instead luxuriant growth and heavy yield in both straw and grain (Table 7). When sulphate of ammonia was

TABLE 6.—*Growth and yield data obtained from four rice plants grown in petroleum cans with cadang-cadang infested and non-infested soil. Cultures watered with aqueous soil extract*

Treatment of media	Culture number	Date of observation and criteria studied							Dry weight of grains	Dry weight of stalks	Presence or absence of cadang-cadang symptoms
		Feb. 4	Feb. 15	Feb. 25	March 7	June 9					
		Height	Height	Height	Height	Height	Number of bearing culms	Number of non-bearing culms			
		cms.	*cms.*	*cms.*	*cms.*	*cms.*			*gms.*	*gms.*	
C-soil, unheated. Plants watered with heated c-soil water extract.	1	21.0	45.5	57.2	63.0	140	12	2	26	39	Present.
	2	23.0	46.2	53.0	65.0	138	13	2	27	40	
	3	22.4	46.5	55.5	61.5	150	14	1	28	42	
Average		22.1	46.1	55.2	63.2	142	13	1.6	27 ±0.38	40.3±0.59	
C-soil, heated. Plants watered with heated c-soil water extract.	1	24.0	42.0	70.2	82.5	201	50	14	121	190	Absent.
	2	23.5	41.3	63.7	77.0	179	52	15	108	162	
	3	22.3	44.9	61.5	80.5	191	55	13	117	185	
Average		23.3	42.7	65.1	80.0	190.3	52.3	14	115.3±2.59	179 ±5.81	
N-soil, unheated. Plants watered with unheated c-soil water extract.	1	21.5	44.0	62.0	80.0	145	12	2	28	50	Absent.
	2	22.2	40.0	53.0	79.0	140	10	1	27	39	
	3	23.0	41.0	59.0	82.0	135	11	3	30	40	
Average		22.2	41.2	61.3	80.3	140	11	2	28.3±0.81	43 ±2.37	
N-soil, heated. Plants watered with unheated c-soil water extract.	1	22.0	45.0	67.0	90.0	201	53	12	111	170	Absent.
	2	24.0	46.0	70.0	85.0	195	50	15	116	185	
	3	23.0	45.0	68.0	90.0	198	55	12	112	175	
Average		23.0	45.3	68.3	88.3	198	52.6	13	113 ±0.93	176.6±2.97	

TABLE 7.—*Effect of commercial fertilizers added to cadang-cadang infested soil upon the growth and yield of four rice plants grown in petroleum cans*

Treatment of media	Culture number	Date of observation and criteria studied							Dry weight of grains	Dry weight of stalks	Presence or absence of cadang-cadang symptom
		Feb. 4	Feb. 15	Feb. 25	March 7	June 9					
		Height	Height	Height	Height	Height	Number of bearing culms	Number of non-bearing culms			
		cms.	*cms.*	*cms.*	*cms.*	*cms.*			*gms.*	*gms.*	
C-soil, unheated, plus sulphate of ammonia and double superphosphate.	1	23.0	51.1	66.5	86.0	175	37	2	63	120	
	2	24.0	48.5	66.0	92.0	180	38	1	62	115	Absent.
	3	25.0	50.0	69.0	94.0	185	32	1	59	102	
Average		24.0	49.8	67.2	90.6	180.0	35.6	1.3	61.3±0.81	112.3±2.25	
C-soil, unheated, plus sulphate of ammonia and sulphate of potash.	1	23.0	50.0	67.0	85.5	188	36	1	56	99	
	2	25.0	50.0	60.0	90.5	180	30	1	65	110	Absent.
	3	24.5	49.0	75.0	94.0	190	40	3	64	114	
Average		24.2	49.6	67.3	90.0	186.0	35.3	1.6	61.6±1.92	107.6±3.02	
C-soil, unheated plus sulphate of potash and double superphosphate.	1	23.4	41.2	52.1	61.5	135	12	2	23	42	
	2	24.0	40.5	51.0	60.0	132	11	1	21	49	Present.
	3	22.9	42.0	50.5	59.5	140	10	0	22	40	
Average		23.4	41.2	51.2	60.3	135.6	11	1	22 ±0.38	43.6±1.83	

C-soil, unheated plus sulphate of ammonia, sulphate of potash and double superphosphate.	1	24.5	42.0	69.0	86.5	170.0	36	2	66	121	
	2	25.0	48.5	70.7	87.0	185	39	2	60	115	
	3	27.0	49.0	75.0	80.0	180	35	3	61	119	Absent.
Average		25.5	46.5	71.6	87.5	178.3	36.6	2.3	62.3±1.25	118.3±1.19	
C-soil, unheated, plus sulphate of ammonia, sulphate of potash, double superphosphate and sulphate of magnesia.	1	24.0	41.0	70.0	85.0	170	36	2	66	120	
	2	23.5	49.0	65.0	79.0	180	29	0	59	105	Absent.
	3	25.0	50. 0	72.0	85.0	190	40	3	60	115	
Average		24.2	46.6	69.0	83.0	180.0	35.0	1.6	61.6±1.47	113.3±2.97	
Average (control table 4)		21.6	38.9	47.5	52.6	126	10.2	2.6	20.4±0.51	45.0±2.27	Present.

TABLE 8.—*Effect of commercial fertilizers added to soil not infested with cadang-cadang upon the growth and yield of four rice plants grown in petroleum cans*

Treatment of media	Culture number	Date of observation and criteria studied							Dry weight of grains	Dry weight of stalks	Presence or absence of cadang-cadang symptom
		Feb. 4	Feb. 15	Feb. 25	March 7	June 9					
		Height	Height	Height	Height	Height	Number of bearing culms	Number of non-bearing culms			
		cms.	*cms.*	*cms.*	*cms.*	*cms.*			*gms.*	*gms.*	
N-soil, unheated, plus sulphate of ammonia and double superphosphate.	1	24.0	52.0	67.5	87.5	185.0	37	1	64	122	Absent.
	2	23.0	52.0	69.0	90.0	190.0	36	1	62	110	
	3	22.0	51.0	67.0	91.0	180.0	40	2	58	109	
Average		23.0	51.6	67.8	89.5	185.0	37.6	1.3	61.3±1.19	113.6±2.81	
N-soil, unheated, plus sulphate of ammonia and sulphate of potash.	1	23.0	52.0	68.5	91.2	190.0	37.0	1	63	120	Absent.
	2	24.0	50.0	69.0	95.0	189.0	35.0	2	60	118	
	3	24.0	50.0	70.0	89.0	192.0	40.0	2	59	101	
Average		23.6	50.6	69.2	91.7	190.3	37.3	2.6	60.6±0.81	113.0±4.06	
N-soil, unheated, plus sulphate of potash and double superphosphate.	1	23.0	48.0	55.0	87.0	140.0	12.0	0	26	40	Absent.
	2	25.0	50.0	54.0	90.0	135.0	14.0	1	29	51	
	3	23.0	47.0	59.0	85.0	150.0	11.0	0	28	45	
Average		23.6	48.3	56.0	87.3	141.6	12.3	.3	27.6±0.59	45.3±4.06	

N-soil, unheated, plus sulphate of ammonia, sulphate of potash and double superphosphate.	1	24.0	52.0	68.5	92.5	185.0	37.0	2	66	120	
	2	25.0	54.0	70.0	88.0	192.0	40.0	2	64	112	Absent.
	3	23.0	51.0	71.0	92.0	189.0	36.0	1	63	100	
Average		24.0	52.3	69.8	90.8	188.6	37.6	2.6	64.3±0.59	110.6±3.92	
N-soil, unheated, plus sulphate of ammonia, sulphate of potash, double superphosphate and sulphate of magnesia.	1	23.0	51.0	71.0	95.0	188.0	38.0	1	64	115	
	2	24.0	53.0	68.0	89.0	190.0	38.0	1	63	110	Absent.
	3	23.5	52.0	69.0	90.0	189.0	42.0	2	62	101	
Average		23.5	52.0	69.3	91.3	199.0	49.3	1.3	63.3±0.41	108.6±2.76	
Average (control table 4)		22.9	43.5	57.5	66.3	131.0	13	2.6	27.6±1.25	62.4±1.46	Absent

absent in the fertilizer combination of sulphate of potash and double superphosphate, the rice plants exhibited poor and chlorotic growth and low yield in both straw and grain (Table 7). The same trend of results was obtained with the N-soil which was fertilized (Table 8).

The addition of sulphate of magnesia to the three fertilizers used (N, P, K) in the C- and N-soils did not improve the yield of the rice plants both in straw and grain. Its absence in the combination in which sulphate of ammonia was a part entirely did away with the chlorotic condition of the leaves. This plant behavior points definitely to the presence in sufficient amounts in the soil of magnesia and that the deficiency in nitrogen in the soil is responsible for the retarded growth of the plants and the chlorotic condition of the leaves, which condition is called, in the Bicol provinces rice *cadang-cadang*.

SUMMARY AND CONCLUSIONS

Field observations and pot culture studies of the so-called rice *cadang-cadang* in the Bicol provinces were undertaken during the years 1935–1936 and 1937–1938.

Rice plants affected with *cadang-cadang* in rice paddies are generally dwarfed and with chlorotic leaves. The older leaves become yellow and only the inner younger leaves remain green. The roots of the plants are mostly brown except those which extend horizontally from the base and which are white and turgid.

Rice *cadang-cadang* was found in the Bicol provinces both in irrigated and unirrigated rice paddies where the surface soil is generally shallow and sandy, measuring about 4 to 5 inches deep. The subsoil is predominantly sandy to gravelly. The rice paddies were generally weedy and oftentimes the weeds became the dominant vegetation.

Rice plants planted in cans containing soil samples obtained from a *cadang-cadang* infested field in the Bicol provinces and watered regularly with water supplied by the Metropolitan Water District produced the symptoms of *cadang-cadang* observed in *cadang-cadang* rice paddies. The aqueous soil extract of soil infested with *cadang-cadang* when administered continuously to rice plants grown in a non-infested soil failed to produce the symptom of rice *cadang-cadang*. Rice grew luxuriantly in heated *cadang-cadang* soil. It appears probable that the heat treatment given to the media has changed, modified or ushered

in a condition whereby the nutritive substances in the soil became available to the rice plants. It may be inferred, therefore, that rice *cadang-cadang* is due to plant food deficiency in the soil.

Soil obtained from the Bicol provinces which is known to produce the symptom of rice *cadang-cadang* in the laboratory failed to cause rice *cadang-cadang* when commercial fertilizer containing sulphate of ammonia was added to it. Fertilizer studies conducted in can cultures point to the conclusion that the soil sample which causes rice *cadang-cadang* is deficient in nitrogen. Phosphorous and potassium in sufficient amounts are present in the soil. All other conditions necessary for growth being normal, the application of from 250 to 300 kilograms of sulphate of ammonia to a hectare of rice paddy will augment the yield materially. This finding is confirmed in field studies, the results of which will be published soon.

Heating *cadang-cadang* soil proves to be helpful and appropriate under laboratory conditions but its practicability in the field is doubted.

ACKNOWLEDGMENTS

The writers wish to express their gratitude to Mr. Francisco Red, then district agronomist of the Bicol region; to Mr. Julian C. Ilagan, acting agricultural supervisor of Albay, and his staff, for their coöperation and help in furnishing the materials needed for the experiment; and to Mr. V. Borja for the help rendered in the computation of the probable error of the yield.

LITERATURE CITED

1. Gustofson, A. F. Effect of drying on soils on water-soluble constituents. Soil Science 13 (1922) 173–213.
2. Steemkamp, J. L. The effect of dehydration of soils upon their colloid constituents. Soil Science 25 (1928) 163–182.
3. Mortensm, A. E., and F. L. Dudley. The effect of drying and ultraviolet light on soils. Soil Science 32 (1931) 195–198.

ILLUSTRATIONS

PLATE 1

Growth behavior of rice plants in the first sample of *cadang-cadang* infested and non-infested soil.

PLATE 2

Growth behavior of rice plants in *cadang-cadang* infested and non-infested soil (normal soil).

PLATE 3

Growth development of rice plants in heated and unheated *cadang-cadang* infested soil.

PLATE 4

Growth development of rice plants in heated and unheated normal soil (*cadang-cadang* free).

PLATE 5

Growth development of rice plants in heated and unheated soil and watered continuously with aqueous soil extract. The first two cultures on the left were watered with aqueous soil extract of heated C-soil. The other two cultures on the right were watered with aqueous soil extract of unheated C-soil.

PLATE 6

Growth development of rice plants in fertilized *cadang-cadang* infested soil.

PLATE 7

Growth development of rice plants in fertilized normal soil (*cadang-cadang* free).

1
NORMAL SOIL
UNFERTILIZED
2
CADANG-CADANG
SOIL UNFERTILIZED
3
NORMAL SOIL
UNFERTILIZED
4
5
6
N
P_2O_5
K_2O
NORMAL SOIL
7
8
9
N
P_2O_5
K_2O
CADANG-CADANG SOIL

PLATE 1.

PLATE 2.

PLATE 3.

PLATE 4.

Not Heated
CADANG-CADANG
SOIL
Heated
CADANG-CADANG
SOIL
Heated
NORMAL SOIL
Not Heated
NORMAL SOIL

PLATE 5.

CADANG - CADANG
SOIL + NPK
CADANG - CADANG
SOIL + NK
CADANG - CADANG
SOIL + N P
CADANG - CADANG
SOIL + PK

PLATE 6.

NORMAL SOIL
NORMAL SOIL
NORMAL SOIL
NORMAL SOIL
NORMAL SOIL
NORMAL SOIL

PLATE 7.

STUDIES ON THE MANUFACTURE OF GUAVA JELLY

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Of the Plant Utilization Division,
Bureau of Plant Industry

THREE PLATES

Growing wild almost everywhere in the Philippines, guava, although abounding during the rainy season, is consumed as food only to a limited extent while the rest goes to waste. One of the preparations of guava well known among Filipinos is guava jelly. It is marketed in flat, round tin cans of friction cover, $4\frac{1}{4}$ inches in diameter and $1\frac{1}{8}$ inches in height. Sold in Manila and in some large towns in the Philippines, this product is manufactured by some Chinese. Interisland steamship companies have contributed to a large extent to the popularity of this jelly, for it is served with cheese and bananas as dessert, practically everyday in almost all the interisland steamships.

The demand for guava jelly has become so great that it is seldom, if ever, absent in all grocery and sari-sari stores in Manila and in large towns of the Philippines. This so-called jelly, being a thick sticky syrup, certainly is a very inferior product, and should be labelled "syrup" rather than "jelly." It lacks the qualities of an excellent jelly, namely, to quiver when shaken, retain the shape of the container when removed from it, show the sides when cut with a knife, and retain the flavor of the fruit.

Although guava jelly is manufactured in this country in rather large quantities, the Philippines import(1) a considerable amount of it from other countries. The following table shows the yearly importation of jams, jellies, and marmalades.

TABLE 1.—*Yearly Philippine importation of jams, jellies, and marmalades.*[a]

Year	Quantity	Value
	Kilos	*Pesos*
1935	147,419	47,529
1936	138,233	50,883
1937 (first quarter)	33,203	13,501
Total	318,855	111,913

[a] Not published as a separate item prior to 1935.

The above data show that in a period of less than three years, the Philippine importation of jams, jellies, and marmalades was worth ₱111,913, a sum which conclusively indicates that these products command a good market in the Philippines.

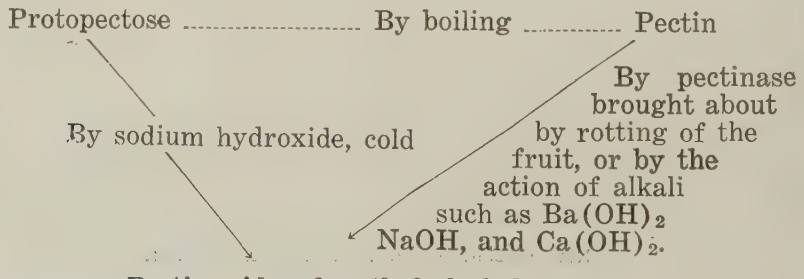
For the purposes of enlightening the present guava jelly manufacturers in utilizing the excess guava, of increasing the farmers' income, and of encouraging ambitious capitalists to manufacture a better quality of jelly for local and for export trade, this study has been undertaken with the hope that in the future, the public will enjoy a real toothsome jelly.

REVIEW OF LITERATURE

Besides water, jelly has three important constituents, namely, pectin, acids, and sugar. Myers and Baker(2) in their work on fruit jellies, prepared an excellent jelly by combining in right proportions, pectin, acid, sugar, and distilled water. Fruit jelly, which is normally lacking in either pectin or acid, does not make a good jelly, but if supplied with any of these substances, a superior product results. From these facts, we can unmistakably infer that many failures in jelly making may be due mainly to the improper application of the above-mentioned substances.

The work of Haas and Hill(3) gives more light to the part played by pectin, acid, and sugar in jelly making. The claim of these authors that unripe fruits contain protopectose, the precursor of pectin and pectic acid, is now universally admitted. Fruits, upon ripening or on being boiled, according to them, transform protopectose into pectin, which together with acid, sugar, and water forms jelly. Again, they verified that prolonged boiling or treatment with an alkali further converts pectin into methyl alcohol and pectic acid, an insoluble substance, which is incapable of forming a jelly. This is one of the causes of the failures in jelly making.

The relations of protopectose, pectin and pectic acid are further illustrated in the following diagram:


Protopectose
By boiling
Pectin
By sodium hydroxide, cold
By pectinase brought about by rotting of the fruit, or by the action of alkali such as Ba(OH)2 NaOH, and Ca(OH)2.
Pectic acid and methyl alcohol

As important as pectin are the acids present in or supplied by the fruits. Goldwaithe(4) illustrated in the following table the effect of the presence of acids in juice on jellies.

TABLE 2.—*Effect of acids on the texture of finished jellies.*

Name of fruit	Acidity as H_2SO_4	Sugar to juice	Texture of jelly
	Per cent		
Crab apple	0.55	1:1	Excellent.
Do	0.00	1:1	Syrupy.
Do	0.27	1:1	Syrupy.
Grape	0.31	1:1	Excellent.
Do	0.00	1:1	Syrupy.

Table 2 proves the importance of the presence of the proper amount of acids in producing perfect jellies. As shown, the juice which formed excellent jelly produced a syrupy product when neutralized with sodium hydroxide.

Both pectin and acid are indispensable in fruit-jelly making. So is sugar. The application of the proper amount of sugar to make a perfect jelly is necessary as shown by Goldwaithe(4) in the following table.

TABLE 3.—*Effect of the proper amount of sugar on the texture of the finished jelly.*

Name of fruit	Acidity as H_2SO_4	Sugar to juice	Texture of jelly
	Per cent		
Crab apple	0.35	¼:1	Tough.
Do	0.35	½:1	Good.
Do	0.35	¾:1	Excellent.
Do	0.35	1:1	Too soft.
Grape	0.49	½:1	Tough.
Do	0.49	¾:1	Good.
Do	0.49	1:1	Excellent.

Table 3 shows that if the proper amount of sugar is added to the juice, an excellent jelly can be made. In the above illustration, crab apple, acidity 0.35 per cent mixed with equal amounts of sugar and juice, produced very soft jelly, whereas, the same amount with ¾ sugar to juice resulted in an excellent product. However, in the case of grapes, acidity 0.49 per cent, the same proportion of sugar to juice gave an excellent jelly.

COMMERCIAL POSSIBILITIES OF GUAVA-JELLY MAKING

The present and future importance of guava-jelly making can be ascertained from the point of view of cost and demand. As for the first consideration, the chances are very favorable, for the price of guava fruit is very cheap and at the same time the supply is unlimited—the only handicap being the lack of cultivated farms, where buying can be concentrated. Other materials needed, like sugar and acid–producing fruits, abound in the Islands. Labor can be secured at comparatively low cost so that under the guidance of an expert, it can be expected to produce good results. In short, so far as the cost of production is concerned, the prospect is bright (see Table 4).

Local and foreign markets are our next consideration. That the local market for manufactured confections is well established is verified in Table 1, which shows that our import of the same amounts to quite a considerable sum of money. With improved quality of jelly, this local demand can be further expanded by educating the people on the food values of native manufactured fruit products, and by making them appreciate and patronize such commodities. The same is true of the demand abroad. All that a manufacturer has to do is to keep up with the standard quality of the foreign made product. The novelty and flavor of the locally made product will enable him to compete favorably with foreign manufacturers. With systematic advertising abroad, guava jelly may prove an indispensable delicacy in foreign homes.

The following table shows the commercial possibility of manufacturing guava jelly. The calculations of cost and selling prices are based on data from a factory that has an output of jelly made from six baskets or "kaings" of guavas.

TABLE 4.—*Cost of production and selling price of guava jelly.*

A. *Cost of production:*	
Guava fruit (1 basket or "kaing" of 23 kilos)	₱0.80
Sugar (second class), ₱0.08 × 21	1.68
Containers (10-oz. cap.), ₱0.09 × 86	7.74
Sources of acid:	
Either tamarind, calamansi juice, santol, or citric acid	0.37
Labels, ₱0.01 × 86	0.86
Fuel (coal)	1.00

Labor:	
Two one-peso laborers	₱0.34
One technical helper	0.34
Miscellaneous	0.20
Overhead (5 per cent of the sum of the above item)	0.66
Total	₱14.99
B. *Selling price* (wholesale) 25 × 86	21.50
Net profit	₱6.51

METHODS EMPLOYED IN JELLY-MAKING

Extractions of guavas with different proportions of water.—Guava, which belongs to a group of practically non-juicy fruits, needs water to extract the pectin, acid, and flavor for jelly making. Thus the determination of the amount of water to be used is the first consideration, for the presence of the right amount determines the grade and quality of the jelly. The following proportions were used in the extractions:

1. Equal amount of guava and water.
2. Utilization of the first and second extracts of the above proportion.
3. One part guava and two parts water.
4. Two parts guava and three parts water.

The fruit is boiled for thirty minutes in any of the above mentioned proportions. Then the juice is strained and with sugar and the amount of acids needed, jellies are made at a jellying point of 108°C.

Utilization of tamarind fruit and calamansi as sources of acids.—In the absence of citric acid, green tamarind fruit was utilized, the percentages of which ranged from 10 to 30 per cent.

The guava fruits were separately boiled for thirty minutes with 10, 15, 20, 25, and 30 per cent green tamarind. The strained juices were separately labelled according to the percentage of tamarind present.

Fresh *calamansi* juice was also used in the absence of either citric acid or tamarind with gratifying results. The amounts used ranged from 3 to 27 tablespoonfuls (1 tablespoonful of *calamansi* juice weighs 12 grams) per kilo of guava juice.

Determination of total acidity.—In order to determine the total acidity of the juice, 10 cc. samples were taken and titrated with one-tenth normal sodium hydroxide solution.

Preparation of jelly.—A standard method of jelly making was followed in all the experiments. It is described as follows:

To one part (by weight) of guava juice one-half part of sugar was added. To this mixture acid in the form of either citric acid or *calamansi* juice was also added to adjust the acidity. Acids present in guava juice are not sufficient to form a satisfactory jelly. The mixture was heated to the boiling point, then strained, and heated again until the jellying point of 108°C. was reached. The finished jelly was transferred in clean dry jelly jars.

RESULTS AND DISCUSSION

TABLE 5.—*Effect of the proportion of guava to water on the texture and color of the jelly.*

Guava to water	Acidity as acetic acid	Citric acid added	Texture of jelly	Color of jelly
Parts	*Per cent*	*Grams*		
1:1	0.34	None	Syrupy	Light amber.
1:1	0.34	2	Excellent	Do.
1:1 (1st and 2nd extracts)	0.30	None	Syrupy	Do.
1:1 (1st and 2nd extracts)	0.30	2	Good	Do.
1:1 (1st and 2nd extracts)	0.30	4	Excellent	Do.
1:2	0.27	None	Syrupy	Lighter amber.
1:2	0.27	2	Good	Do.
1:2	0.27	4	Excellent	Do.
2:3	0.28	None	Syrupy	Do.
2:3	0.28	2	Good	Do.
2:3	0.28	4	Excellent	Do.

Table 5 indicates that in the proportions 1:1, 1:2, and 2:3 (guava to water) guava alone cannot produce satisfactory jelly, but with the addition of certain amounts of citric acid, any proportion up to 1:2 produces perfect jellies. It has also been proved that guavas contain much pectin so that even the proportion 1:2, with four grams of citric acid, produces a good quality of jelly. Guava juice, therefore, diluted with water cannot produce excellent jelly unless acid is added to it.

Utilization of calamansi and tamarind.—For the purpose of utilizing some indigenous fruits in supplying acidity to guavas, *calamansi* and green tamarind were separately used. Different amounts of *calamansi* juice were added in order to determine the limits at which a good jelly could be prepared.

TABLE 6.—*Effect of the different amounts of calamansi juice on the texture and color of the jelly.*

Juice to sugar	Calamansi juice added	Acidity as acetic acid	Texture of jelly	Color of jelly
Kilos	*Tablespoons* [a]	*Per cent*		
1:½	None	0.31	Syrup	Lighter amber.
1:½	3	0.43	Good	Do.
1:½	6	0.53	Excellent	Do.
1:½	9	0.65	do	Do.
1:½	12	0.79	do	Light amber.
1:½	15	0.83	do	Do.
1:½	18	1.00	do	Do.
1:½	21	1.19	do	Do.
1:½	24	1.30	do	Sl. dark amber.
1:½	27	1.43	do	Do.

[a] One tablespoon of *calamansi* juice equals 12 grams, approximately 12 cc.

Table 6 again proves that guavas alone cannot produce a good quality of jelly as they lack acid. However, an excellent guava jelly can be prepared with *calamansi* juice ranging from 6 to 27 tablespoonfuls or an average of 3 to 14 *calamansi* fruits per kilo of guava juice. It is distinctly shown that the intensity in color(5) and transparency(6) of the jelly increases as the amount of *calamansi* juice is correspondingly increased.

TABLE 7.—*Effect of different amounts of green tamarind on the texture and color of the jelly.*

Tamarind in guava	Juice to sugar	Acidity as acetic acid	Texture of jelly	Color of jelly
Per cent	*Kilos*	*Per cent*		
10	1:½	0.47	Good but turns sugary	Lighter amber.
15	1:½	0.49	Excellent	Do.
20	1:½	0.55	do	Do.
25	1:½	0.60	do	Deep amber.
30	1:½	0.69	do	Do.

As shown in the above experiment, tamarind, another sour fruit serves satisfactorily in supplying acidity to guavas. In the experiment, different percentages of tamarind were used during the preparation of the guava fruit extraction with water. Jellies made with acids from tamarind, besides being excellent, contain more food value than those to which citric acid has been added.

It can be seen that jellies made with from 15 to 30 per cent tamarind are all excellent from the standpoint of color, transparency, and texture. It was noted that as the amount of tamarind was increased, the intensity in color (5) and transparency (6) correspondingly increased. It is, however, recommended that for sweet jellies, 15 to 20 per cent tamarind should be used; for slightly sour ones, 25 to 30 per cent.

The effect of different kinds of containers on the color of the finished jelly.—In this experiment three kinds of containers were used, namely, copper (tacho), enameled and aluminum. Different kinds of juices (obtained by preparing the extraction from the fruit with different proportions of water) were employed for the purpose of determining which would produce better results; the first extract, or the first and second extracts combined.

TABLE 8.—*Effect of copper, enameled, and aluminum containers on the color of the jelly.*

Acidity as acetic	Citric acid added	Kind of juice	Types of containers	Color of jelly
Per cent	*Grams*			
0.33	2	1st extract	Aluminum	Amber.
0.28	4	1st and 2nd extracts	Aluminum	Light amber.
0.33	2	1st extract	Copper	Amber.
0.28	4	1st and 2nd extracts	Copper	Light amber.
0.33	2	1st extract	Enameled	Amber.
0.28	4	1st and 2nd extracts	Enameled	Light amber.

Table 8 shows that the jellies prepared with the first extract in aluminum, copper, and enameled containers were all amber and of the same intensity. On the other hand, those with the first and second extracts combined were all light amber. We can safely infer that the kind of container does not affect the color of the jelly, but that the kind of juice employed does affect it.

The effect of sugar, high and low grades on the color, texture, and transparency of the jelly.—In this experiment, expensive sugars, such as suchar, and snowflakes, together with second class washed sugar were used in order to determine their effects on the color, texture, and transparency of the jelly. Citric, tartaric, and sulphuric acids were also used.

TABLE 9.—*Color of guava jelly made with different kinds of sugar and acids.*

Kinds of acids	Kinds of sugar	Acidity as acetic acid	Acid added	Color of jelly
		Per cent	*Grams*	
Citric	Washed	0.23	4	Light amber.
Do	Suchar	0.23	4	Do.
Do	Snowflakes	0.23	4	Do.
Tartaric	Washed	0.23	4	Do.
Do	Suchar	0.23	4	Do.
Do	Snowflakes	0.23	4	Do.
Sulphuric	Washed	0.23	4	Do.

Table 9 shows that jellies made with washed, suchar, and snowflakes sugars were all of the same color (light amber) and transparency regardless of the acid used, with the exception of sulphuric acid, which hydrolyzed the pectin and caramelized the sugar, completely spoiling the product and making it unfit for human consumption. The kind of useful acids and sugar have, therefore, no material effect on the color and quality of the jelly. However, especially in commercial scale production, tartaric acid [b] and washed sugar are highly recommended for guava-jelly making, for they are comparatively cheaper than citric acid, suchar, and snowflakes sugars.

TABLE 10.—*Relative color intensity of guava jelly depending upon the kinds of brown sugar used, utilizing 15 per cent tamarind as a source of acids.*

Juice to sugar	Kinds of sugar [c]	Acidity as acetic	Texture of jelly	Color of jelly
Kilos		*Per cent*		
1:½	Washed No. 2	0.46	Excellent	Light amber.
1:½	Brown No 3	0.46	Good	Dark brown.
1:½	Brown No. 4	0.46	Fair	Darker brown.

[c] Washed sugar No. 2 is light brown; No. 3 is brown; and No. 4 is dark brown.

As shown in the above table, the jellies made with brown sugar Nos. 3 and 4 were inferior in color and transparency to those made with washed sugar. The latter then, in spite of cost, should be utilized if the manufacturers intend to produce an excellent guava jelly.

[b] Tartaric acid costs ₱1.40 per kilo; citric acid, ₱1.75.

The utilization of peeled guavas.—For peeling the guavas, 3 per cent sodium hydroxide was used. This process of peeling takes very much shorter time than with paring knife. The peeled guavas, after having been washed several times with running tap water to remove completely the alkali, were made into jelly in the same way as the unpeeled guavas. The very attractive color and transparency of the jellies which resulted from the peeled guavas compensated for the labor employed and the extra material used.

The effect of heat on the color of the jelly.—Inasmuch as the degree of heat needed, the time consumed in cooking the jelly, and size of the batch used are important factors in the commercial production of guava jelly, without endangering the quality of the finished product, experiments utilizing different degrees of heat and sizes of batches were undertaken. For a high degree of heat, the gas stove in the kitchen of the Plant Utilization Division, Bureau of Plant Industry, was employed.

TABLE 11.—*Effect of very low, moderate, and very strong heat on the color of the finished jelly.*

Size of batch	Acidity as acetic acid	Citric acid added	Heat	Time		Color of jelly
Kilos	*Per cent*	*Grams*		*Min.*	*Sec.*	
2	0.27	8	Moderate	32		Light amber.
2	0.27	8	Very strong	15	30	Deep amber.
2	0.27	8	Very low	50		Deeper amber.
5	0.27	20	Very strong	44	30	Deeper amber.

The above table shows that in order to obtain a jelly of light amber, a very attractive color, moderate heat with a two-kilo batch is indispensable. Very intense heat, on the other hand, results in the slight caramelization of the sugar, a condition which accounts for the slightly darker color of the jelly. The same size of batch, two-kilo juice, cooked over very low fire gives a slightly deeper amber. A five-kilo juice cooked over very strong fire produces a slightly deeper colored jelly, which is still attractive. The latter experiment is suggested for commercial scale production, for the time consumed is only 44½ minutes, a period short enough to enable the factory to make many batches during the day.

The effect of sulphuric acid on the color and grade of jelly.—The application of sulphuric acid varied from one to four grams per kilo of guava juice. In this experiment different amounts

of sulphuric acid were used instead of other kinds of acids, such as citric and tartaric acids, or acids from either *calamansi* or tamarind, in order to supply the guava juice with acid.

TABLE 12.—*Color of the jelly and time consumed when sulphuric acid was added.*

Size of batches	Acidity as acetic acid	Sulphuric acid added	Time		Texture of jelly	Color of jelly
Kilos	*Per cent*	*Grams*	*Min.*	*Sec.*		
1	0.27	1	13	10	Soft	Too light.
1	0.27	2	18	30	Excellent	Amber.
1	0.27	3	20	50	Good	Brown.
1	0.27	4	21	30	Syrupy	Very dark (caramelized).

Table 12 shows that the color of the finished product depends upon the amount of sulphuric acid used; that is, the lesser the acid, the lighter the color of the jelly. Jellies made with two grams of sulphuric acid are the best in texture, transparency, and color, but those with four grams are very dark and syrupy. This fact is due mainly to the partial hydrolysis of the pectin with subsequent caramelization of the sugar which in turn, causes the dark coloration.

SUMMARY AND CONCLUSIONS

1. Perfect jellies can be made from guavas, even in the proportion of 1:2 of fruit to water, using four grams of either citric or tartaric acid, or *calamansi* juice, or green tamarind.

2. The use of the proper amounts of pectin, acid, and sugar is essential in the manufacture of excellent guava jelly.

3. In the absence of either tartaric or citric acid, both tamarind and *calamansi* juice serve as subtitutes in the production of a perfect guava jelly.

4. Copper, enameled, and aluminum containers when used in cooking the jelly do not materially affect the color, transparency, and texture of the finished product.

5. First-class sugar has no material advantage over washed sugar from the point of view of color, transparency, and texture.

6. Peeled guavas produce lighter colored jelly than the unpeeled ones.

7. Very strong or very low fire tend to produce a very much darker colored product than that with moderate heat. The bigger the size of a batch, regardless of the degree of heat used, the darker the color of the jelly.

8. Sulphuric acid with guava juice makes a perfect jelly, when two grams only of the acid are used per kilo of juice. Very much sulphuric acid, exceeding four grams, is detrimental to the quality of the jelly, for the excess tends to produce a syrupy product, very dark and caramelized.

9. The manufacture of guava jelly has a promising commercial future.

LITERATURE CITED

1. Annual report of the Insular Collector of Customs. Bureau of Printing. Manila. 1937.
2. Myers, P. and G. Baker. Fruit jellies. Univ. Del. Agr. Expt. Sta. Bull. 168 (Tech. Series Bull. 12) 1931.
3. Haas, P. and T. H. Hill. Introduction to the Chemistry of Plant Products. 1929. 2nd ed., V + 220 p., 12 fig. London, New York & Toronto: Longmans Green & Company.
4. Goldwaithe, N. E. Contribution to the chemistry and physics of jelly making. Jour. Ind. Eng. Chem. 1 (1908) 330–340.
5. Tar, L. W. Fruit jellies. Del. Expt. Sta. Bull. 134 (Tech. Series Bull. 2) 1923.
6. Tar, L. W. Fruit jellies. Del. Expt. Sta. Bull. 142 (Tech. Series Bull. 5).

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ILLUSTRATIONS

PLATE I

Branches of guava trees in fruit.

PLATE II

FIGS. 1–2. Cenco balance and a copper vat (*tacho*).

PLATE III

FIGS. 1. Finished guava jelly in glass containers.
2. Inverted guava jelly. Note the sharp edges when cut.

PLATE 1.

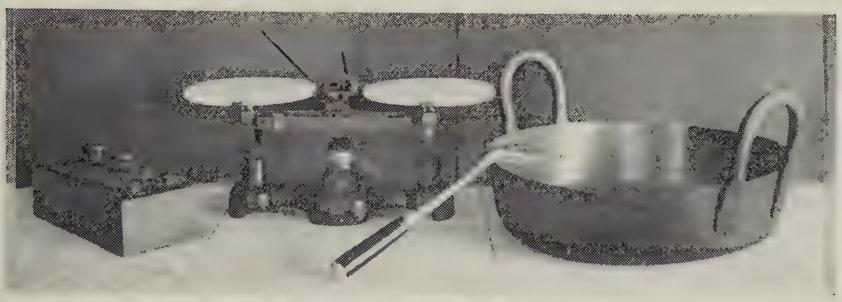

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PLATE 2.

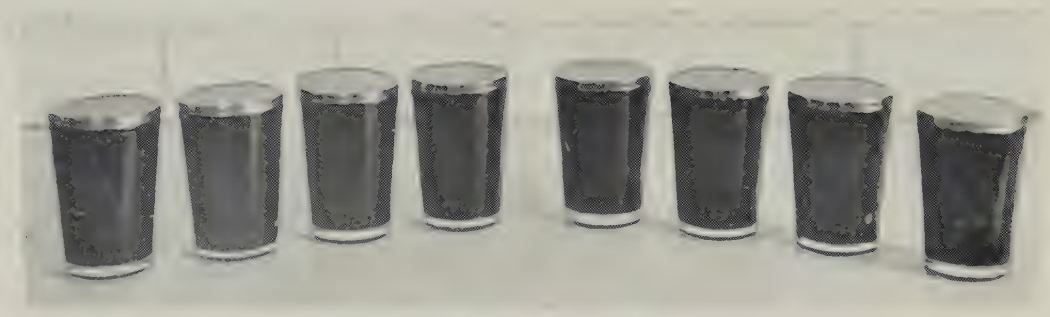

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PLATE 3.

NOTES ON THE ROTENONE CONTENT OF CEBU DERRIS

By Juan M. Ejercito
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TWO PLATES

Until the end of the year 1937, Cebu led in the area planted to derris in the Philippines. No less than 600 hectares were under cultivation, of which the towns of Barili, Minglanilla, Toledo, and Talisay led in the order of their enumeration. Talisay and Minglanilla were the first towns to have extensive derris fields. (See Plates 1 and 2.) Commercial consignments of derris roots from Cebu have shown a toxic content which is quite acceptable in the market. For this reason, Cebu became one of the principal sources of planting materials (stem cuttings) for the different provinces. Most of the orders were placed through the Bureau of Plant Industry, Manila or through its branch office in Cebu. However, in some cases the materials were purchased direct from some private planters in Cebu. For the benefit, therefore, of those who bought planting materials of Cebu derris, and those would-be derris planters, this paper has been prepared with the aim in view of showing the rotenone content of Cebu derris planted in different parts of the Philippines.

MATERIALS

The derris referred to in this paper is supposed to be a strain of *Derris elliptica* (Roxb.) Benth. It is called "Pilipogon" in Cebu. Most of the materials supplied to fill up the orders made through the Bureau of Plant Industry were of this strain. Another strain which is equally as good as "Pilipogon" is "Ikog-ilaga." Both are widely planted in Cebu. They resemble very much each other in their mode of growth, number, size and shape of leaflets except in the shape of the vines and roots. "Ikog-ilaga" can be identified by its roots and stems which taper more abruptly towards the tip than those of "Pilipogon." This abrupt tapering seems to be due to its shorter internodes.

DISTRIBUTION OF MATERIALS

In Table 1 are shown derris planters in different parts of the Philippines, and the extent of their plantings as judged by the number of cuttings ordered.

TABLE 1.—*Planters of Cebu derris in various parts of the Philippines*

Planter and address of farm	Quantity bought	Date bought
Victor de los Reyes, Nampicuan, Cuyapo, Nueva Ecija	1,000	July ,1935.
Calamba Sugar Estate, Canlubang, Laguna	20,000	August, 1935.
C. Sandiko, Balas, Mexico, Pampanga	2,000	October, 1935.
A. Escudero, Tabasin, Tiaong, Tayabas	2,000	November, 1935.
Philippine Milling Company, San Jose, Mindoro	240,000	December, 1935.
L. Espejo, Umingan, Pangasinan	10,000	June, 1936.
P. San Agustin, Concepcion, Sariaya, Tayabas	5,500	July, 1936.
Granja Sugar Cane Expt. Station, La Carlota, Occ. Negros	50,000	September, 1936.
D. Sy Cip, Dumaguete, Oriental Negros	4,000	Do.
Jose Dizon, Calasiao, Pangasinan	200	Do.
R. Tumbokon, Agbago, Ibajay, Capiz	10,000	October, 1936.
M. G. Blardony, Balara, Mariquina, Rizal	1,650	April, 1937.
M. G. Blardony, Magallanes, Cavite	48,000	May, 1937.
G. Pondoc, Sta. Ana, Davao	Bought direct from Cebu.	

RESULTS

Table 2 presents the results of analyses of "Pilipogon" derris as grown in different sections of the Philippines outside of Cebu Province while Table 3 shows the analysis of the same derris variety as grown in Cebu.

TABLE 2.—*Results of analyses of roots of Pilipogon variety in different places (moisture free basis)*

Place of farm	Type of climate	Kind of soil	Age harvested	Ether extract	Rotenone
			Months	*Per cent*	*Per cent*
San Jose, Mindoro	First type [a]	Sandy loam	21		[d] 8–10
Do	do	do	25		[d] 4.50
Calamba, Laguna	do	Mixture of loam and adobe.	16	10.68	5.00
Magallanes, Cavite	do	Clay loam	10½		3.87
Balara, Mariquina, Rizal	do	Red clay loam	13	16.07	[e] 4.69
Nampicuan, Nueva Ecija	do	Clay loam	24		2.65
Balas, Mexico, Pampanga	do	Sandy loam	12	11.44	3.54
Umingan, Pangasinan	do	Silt loam	24	10.00	5.35
Calasiao, Pangasinan	do	Sandy loam	21	28.30	9.45
La Carlota, Occ. Negros	do	do	18	37.91	4.18
Agbago, Ibajay, Capiz	Intermediate A–type [b]	do	24	3.56	1.76
Tabasin, Tiaong, Tayabas.	do	Clay sandy loam	24	31.12	8.39
Dumaguete, Or. Negros	do	do	24	40.34	5.13
Concepcion, Sariaya, Tayabas.	Intermediate B–type [c]	Black silt loam	18	21.10	[f] 8.05
Sta. Ana, Davao	Intermediate B–type [c]	Sandy loam	24	34.03	6.59

[a] Two pronounced seasons: dry in winter and spring (December–May), wet in summer and autumn (June–November).

[b] No very pronounced maximum rain period; with a short dry season lasting only from one to three months.

[c] No very pronounced maximum rain period and no dry season.

[d] Analyzed by Botica Boie Laboratory.

[e] Analyzed by Warner Barnes Laboratory.

[f] Analyzed by College of Agriculture, U. P.

The others not indicated were analyzed by the Chemistry Section, Bureau of Plant Industry.

TABLE 3.—*Results of analysis of derris roots of Pilipogon variety as grown in Cebu (moisture free basis)*

Place of farm	Type of climate	Kind of soil	Age harvested	Ether extract	Rotenone
			Months	*Per cent*	*Per cent*
Tabunok, Talisay	Intermediate A–type [b]	Calcareous	12	17.67	4.90
Do	do	do	24	11.90	3.50
Bulakao, Talisay	do	do	24	20.17	5.74
Do	do	do	24	35.35	4.63
Talisay	do	do	24	37.70	4.46
Tabunok, Talisay	do	do	24	20.10	2.49
Do	do	do	18	24.46	8.04
Do	do	do	48	19.64	6.03
Talibon	do	do	24		[c] 8.26
Danao	do	do	24		[c] 3.33
Medellin	do	do	24		[c] 2.18

[b] No very pronounced maximum rain period with a short dry season lasting only from one to three months.

[c] Analyzed by the Bureau of Science. Ether extract is not available.

TABLE 4.—*Lime content of soil samples and percentage of rotenone content of derris grown in different places*

Places	Lime (CaO)	Ether extract	Rotenone
	Per cent.	*Per cent.*	*Per cent.*
Bulakao, Talisay, Cebu	9.38	24.46	8.04
Tabunok, Talisay, Cebu	3.16	19.64	6.03
Marigondon, Opon, Cebu	1.66	21.80	4.87
Carmen, Bohol	0.138	18.90	1.61

DISCUSSION OF RESULTS

As shown in Tables 2 and 3 the rotenone content of Cebu derris (Pilipogon variety) as grown in different places varied considerably. In Cebu Province itself, the native habitat of the variety under consideration, the rotenone content varied from 2.18 per cent to 8.26 per cent. Of the different places where samples for analysis were taken, 64 per cent showed commercial rotenone content while 36 per cent were below commercial grade.[1] (Table 3). Likewise, the samples from different places outside of Cebu showed the same wide variation in rotenone content. For example, in the sample from Agbago, Ibajay, Capiz, the rotenone content was as low as 1.76 per cent while that from Calasiao, Pangasinan gave an exceptionally high rotenone content of 9.45 per cent (Table 2). Seventy-three per cent of the localities outside of Cebu which grew Cebu derris produced roots having commercial rotenone content and the remaining 27 per cent yielded low-rotenone producing roots (Table 2).

These results are very significant; they show that Cebu derris may not be of only one variety or strain but of different strains of divergent rotenone content, or that the rotenone content of the derris plant may be affected by soil conditions and age at harvest. With respect to the existence of different strains, this is very possible because prior to the cultivation of derris which is very recent, its propagation was left to nature, and in all likelihood this was by sexual means or by seeds. If the variation in rotenone content is due to the existence of different strains, this is a healthy sign as it will eventually lead to the isolation of strains of high rotenone content. Already, work along this line is in progress and its results will be published in the near future.

It is also equally possible that the soil and its composition are factors greatly affecting the rotenone content of derris. Preliminary results obtained from the analysis of soil samples from different derris fields in Cebu and Bohol seem to indicate that soils having a considerable amount of lime have a decidedly higher rotenone content than those with less lime. (See Table 4.) These results will be verified further.

Likewise, the age at harvest time may affect the rotenone content of derris. In Malaya, it has been found out that the optimum age for harvesting is 25 months, considering of course the yield of roots and the total amount of ether extract.[1] Similar study is being undertaken by the Bureau of Plant Industry.

SUMMARY

1. The rotenone content of Cebu derris (Pilipogon variety) has been studied.

2. There exists a wide variation in rotenone content of the different samples analyzed.

3. Sixty-four per cent of the samples taken from the different localities in Cebu were commercial and the remainder were non-commercial. Of those grown in the different provinces outside of Cebu, 73 per cent were commercial.

4. Variations in rotenone content may be attributed to difference in strains, age at harvesting, and soil conditions.

5. Isolation and multiplication of only the highest yielding strains or variety should be practiced to produce a standard variety.

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[1] GEORGI, V. D. C. and A. E. CURTLER. The periodic harvesting of tuba root. Malayan Agr. Jour. 17 (1929) 326–334.

ACKNOWLEDGMENT

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ILLUSTRATIONS

Plate 1

A partial view of an extensive derris plantation (two years old) in the mountains of Lagtang, Tabunok, Talisay, Cebu. Note the thick growth that covers entirely the ground.

Plate 2

A view of a commercial derris plantation in Minglanilla, Cebu. Note the interplantings of corn and banana.

PLATE 1

PLATE 2.

CORN CULTURE IN THE PHILIPPINES

(Farmers' Circular No. 24 (Revised)

THREE PLATES

Corn is the second grain crop of the Philippines in importance. In the provinces of Cebu, Bohol, Siquijor, Cagayan, Isabela, and Abra, it leads rice as a staple food but in other places in the Philippines it is second to rice. The ten principal corn growing provinces in the order of their importance are Cebu, Leyte, Negros Oriental, Negros Occidental, Iloilo, Cagayan, Isabela, Batangas, Pangasinan and Occidental Misamis. Corn is so well adapted to the climatic and soil conditions in the Philippines that its production can be increased many times:

Cultivated area and production

Item	1936	1937
Area cultivated---Hectares	685,010	659,400
Production---Cavans	6,370,690	7,678,080
Average yield per hectare---Cavans	9.30	11.64
Value of production	₱15.713.850	₱17,983,350

Philippine importation of corn

Year	Quantity	Value
	Kg.	
1931	6,372,941	₱177,090
1932	137,786	180,348
1933	7,154,981	207,681
1934	160,687	39,963
1935	222,830	61,715
1936	208,929	53,757
1937	181,401	47,089

Types of corn.—There are four types of corn under cultivation which are of commercial importance. They are the flint, dent, sweet and pop corn. The other types, such as soft corn and pod corn are of no commercial importance.

Flint corn is characterized by a flinty or hard endosperm. It is of various colors, the most common of which are yellow and white. Flint corn is the common type being raised in the

Philippines. The Cebu white flint is better than any of the other varieties of flint corn because good quality *bugas* corn (corn rice) could be obtained from it. The most important varieties of the flint type are the Cebu white, Bohol white, Cagayan white, Calipus white, Moro white and Calamba yellow.

Dent corn, as distinguished from the flint corn, has a horny endosperm at the sides and a starchy endosperm in the middle toward the top. The shrinkage of the starch at the crown on drying leaves the kernel dented. Dent corn is very susceptible to weevils. Hence the reluctance of farmers to plant it. Honduras Nos. 1 and 2 which were recently introduced into the Philippines show signs of promise while the American Mestizo white semi-dent, also recently introduced, is now under extensive cultivation in Lanao, Mindanao.

Sweet corn is characterized by the wrinkled condition of the kernel caused by drying. It is raised on a small scale in many parts of the Philippines. Surecropper and Honey June, recently introduced from the United States are now successfully grown in this country.

Pop corn is characterized by an excessive amount of corneous endosperm, and the small size of the kernel and the ear. The popping is caused by an expansion of the moisture inside the kernel upon heating. One type of pop corn is the rice pop corn which has pointed kernels. The other type is the pearl pop corn which is very similar to small flinty corn. The Golden Queen and the Yellow pop corn are two other varieties grown in the Philippines. Small areas throughout the country are planted to pop corn just to meet local demand.

Glutinous corn, as its name indicates is more or less gluey when cooked. This variety is soft and is used much for green corn. It is in great demand in the market. The plants are of medium height and begin to tassel in 45 to 50 days after planting. The crop matures in 90 to 110 days. The ear measures 4 to 5 cm. in diameter and from 10 to 16 cm. long. It tapers gradually towards the tip. It is fairly distributed in the Ilocos provinces, Cagayan Valley, Batangas and in some parts of the Philippines. The average yield is about 15 cavans per hectare.

Seed corn.—Seed corn should be selected from standing stalks in the field. It should be well-formed, mature and from strong, vigorous and healthy plants. Plants which topple over, and have tendency to sucker as well as plants showing disease symptoms should not be chosen. Diseased plants are likely to produce

diseased seeds which, when used as seeds, may produce stunted and unproductive plants. The selection of seed corn should be done during the ripening period of the crop.

Ears for seed should be tightly covered with husks two to three inches beyond the tip and should be borne on a strong, healthy shank forming a medium angle with the stalk. A good ear for seed is one which is symmetrically developed, cylindrical in form, with straight and full rows of kernels from the butt to the tip. The kernels should be uniform, deep and rectangular in shape. The grains should be bright in color, plump and with well developed germs. Low-borne ears usually mature earlier than those high on the stalk.

The ears for seed should be left in the field to mature thoroughly. In gathering them, there should be left with the ears a small portion of the stalk with which they can be hung or placed in "halayhay" with the husk. In this way the ears should be kept stored and exposed to the sun to dry. Bunching together the unhusked ears and hanging them over a native stove is very effective in preserving seed corn. The smoke drives away weevils and other insects which attack the corn while the heat keeps the ears dry.

The "can method" of storing seed corn was found very satisfactory under Philippine conditions. By this method, the ears are shelled when they are reasonably dry. The grains are dried thoroughly in the sun on mats, cement floors, iron sheets, or any materials that can hold them. When the grains are thoroughly dry, they are put in empty cans with two or three naphthalene balls. The cans are sealed immediately with wax or paraffin. Gasoline or petroleum cans are very handy for this purpose.

Soil requirements.—While corn may be grown anywhere in the Philippines, a level or undulating ground that is well drained would be most ideal. The soil should be clayey, silty, or sandy loam with plenty of organic matter.

FERTILIZERS FOR CORN

Corn takes away from the soil large quantities of nitrogen, phosphorous and potash so that unless these elements are returned to the soil, either by the use of commercial fertilizers or manures, the soil will be depleted of them and corn growing will no longer pay.

The application of animal manure and compost will help in the maintenance of soil fertility.

Commercial fertilizers are very popular and are extensively used in sugar-cane growing. Rice planters are now beginning to use fertilizers too. According to Vibar, a mixture of 10 parts nitrogen, 6 parts phosphoric acid and 2 parts potash is as good as any combination that can be made in the absence of definite knowledge of the composition of the soil. One spoonful of fertilizer per hill has been found to be sufficient. At this rate of application, 100 kilograms of fertilizer will suffice for a hectare. Applications by the one-spoon-per-hill method, although requiring more time than the broadcast or the furrow method, are more efficacious and less wasteful than the latter.

Preparation of the soil.—The soil should be prepared thoroughly; the old corn stalks completely plowed under and allowed to rot and become incorporated with the soil. In the case of corn plantations which are infested with pests and diseases the old stalks should be burned.

It is advisable to prepare the soil during the beginning of the rainy season in April so that planting could be done during the first week of May.

At least three plowings are necessary to raise a good crop, especially in depleted soils. Thorough preparation of the soil gives the corn plant a good start and keeps down the weeds.

Planting.—The time for planting corn depends on the rainfall. In places where there is a distinct dry and wet season, two plantings of corn could be done on the same piece of land during the year, the first planting to be done at the beginning of the rainy season in April or May, and the second in October or November. The first planting is called the rainy season crop and the second, the dry season crop. In places where the rainfall is uniformly distributed throughout the year, where there is no distinct dry season, planting could be done at any time of the year.

Corn is planted in furrows about 90 to 100 centimeters apart and 60 to 70 centimeters between hills. Two to three seeds are planted to a hill at a depth of about 3 centimeters. Small varieties should be planted closer than large varieties. In rich soil they should be planted farther apart than in poor soil.

About six to seven gantas of seeds are needed to plant a hectare.

Cultivation and care of plantations.—The first cultivation is done when the plants are 15 to 20 cm. in height. Corn is a surface feeder, so that cultivations should not be made so deep

as to cut a considerable portion of the roots. A cultivator should be used in preference to the plow. In most places a plow is used in turning over the soil toward the rows of plants. During dry spells, the surface soil should be kept in fine tilth to provide the necessary soil mulching.

Method of cropping corn.—Corn should not be planted continuously on the same land from year to year as this will deplete or wear out the soil more quickly than when different kinds of farm crops are planted in rotation with it. Legumes as green manure should be plowed under 3 to 4 months before planting corn. It is recommended that every fourth crop on the same land should be leguminous. Peanut, mungo and cowpeas are good rotation crops for corn.

Harvesting and storing.—Ordinary varieties of corn mature in 85–110 days from the time of planting. The ears should be allowed to dry thoroughly in the fields before harvesting. Moist-ears or grains mold, and if stored, will either rot or germinate. During the rains in places where there is no distinct dry and wet season, considerable difficulty is encountered in drying corn. This difficulty can be minimized by having proper drying places and ample provisions of seed.

Harvesting is done by hand. The ears are detached from the stalks, husked and dried in the sun preparatory to shelling for the market. The shelling is done with the use of a hand-operated shelling device or machinery. The drying of the grains is completed after shelling. It is then ready for market. Marketing corn as ears is frequently done, if the grain is intended for seed.

In small plantations, corn can be conveniently kept on the "halayhay." The unhusked ears are set on bamboo slats under a shed or in open air.

Pests and diseases.—The corn plants are attacked by corn borers, cut worms, silk beetles, leafhoppers and aphids, and affected by corn smut, leaf-spots, downy mildew and blight. The grain is damaged by corn weevil.

The corn borer (*Pyrausta nubilalis* Rubn.).—The corn borer is one of the worst enemies of corn. The larvæ attack the stalk, tunnel up toward the tassel, bore into the stalk, and finally damage the ears. Infested plants are weakened so much that sometimes even an ordinary gust of wind can break the stalks. Indications of an infested field are broken tassels and the presence of frass or sawdust-like materials at the opening of the tunnel.

Control measures.—Infested corn stalks should be cut close to the ground and fed to animals. Those that are not eaten in the stables should be burned or buried deep so as to destroy all the larvæ and pupæ which may be present. The introduction of egg parasites will materially aid in the extermination of this pest. This requires the services of trained entomologists. Clean culture and the production of resistant varieties should not be overlooked.

The corn silk beetle (*Monolepta bifasciata* Hornst.).—This beetle was found to be very injurious to corn crops. The insects feed on the silk of the young ears and thus prevent fertilization.

Control measures.—The beetles can be controlled by attracting them to lights at night. It is suggested that the time of planting be arranged in such a way that the production of ears does not coincide with the abundance of the beetles. Trap crops, such as "kamoteng kahoy" could be used to great advantage.

These beetles also attack the young leaves of mango. When found abundant on this tree, they should be sprayed with arsenical insecticides or soap solution and derris so that the beetles would have no chance to infest corn fields.

True army worms (*Cirphis unipuncta* Haworth).—The larvæ of this insect attack all grass crops especially corn, rice and many other plants. When the larvæ infest corn crops, they defoliate the young corn plants thereby reducing greatly the vitality of the plants and consequently affecting adversely the harvest.

Control measures.—The adults could be controlled by the use of light traps. The larvæ could be killed by the use of poison bran mixture of the following composition (to be scattered in the field at the rate of 3–4 kilos to the hectare):

Dry bran	lbs.	25
Water	gallons	3
Molasses	quarts	2
White arsenic or Paris green	lb.	1

Dusting the plants with calcium arsenate-*gawgaw* dust mixture is also effective.

The rice or corn weevil (*Calandra oryzae* Linn.).—This is the worst enemy of stored corn, rice and many other stored grains. The larvæ tunnel into the kernels and consume all the contents

before they are transformed to pupæ while the adults puncture the kernels with their beaks for oviposition purposes.

Control measures.—To control the pest one is advised to:

(1) Dry thoroughly before storing corn ears or kernels.

(2) Store corn in tightly closed containers.

(3) Fumigate with carbon bisulphide at the rate of one tablespoonful for every cubic meter of space.

(4) Store seed corn with naphthalene balls.

Downy mildew (*Sclerospora philippinensis* Weston).—This is a serious disease of corn and is found to be severe during rainy season. The upper young leaves of the plants are the first to be affected. Diseased leaves are characterized by the presence of white stripes running parallel to the margin of the leaves. Oftentimes, the entire young leaves are whitened. A downy appearance is produced on the lower surfaces of the leaves by the mass of conidia and conidiophores.

Control measures.—All infected plants should be gathered and burned. Clean culture and crop rotation are recommended to prevent infection.

Leaf blight (*Helminthosporium inconspicum*).—Leaf blight is a common disease of corn, which at times may be extremely destructive. This disease is especially severe on newly introduced corn varieties. The disease is manifested by the presence of minute roundish brown spots, which gradually increase in size. Old spots and stripes have a lighter yellowish to gray center, bordered with brown.

Control measures.—Crop rotation should be practiced. Compost made up of diseased plants should not be applied the same year to fields intended for corn.

Other diseases of corn such as dry rot and smut are of minor importance.

Cost of production.—The cost of producing corn includes the cost of seeds, preparing the soil, planting, cultivating and weeding, harvesting, and other expenses. While it is true that there are many factors affecting the cost of production, the most important are the kind of seeds used, weather conditions, pests and diseases, fertility of the soil, cost of labor, system of tenancy and the market price.

The cost of producing corn per hectare at the Maligaya Rice Experiment Station, Bureau of Plant Industry, Muñoz, Nueva Ecija, is as follows:

Operation	Man labor		Animal Labor		Total cost	Implements
	Days	Cost	Days	Cost		
		Pesos		*Pesos*	*Pesos*	
Land preparation:						
1st plowing, 1st harrowing	10	6.00	10	6.00	12.00	Wooden plow and wooden harrow.
2nd plowing, 2nd harrowing	10	6.00	10	6.00	12.00	Do.
3rd plowing, 3rd harrowing	6	3.60	6	3.60	7.20	Do.
Furrowing	1.5	.90	1.5	.90	1.80	Wooden plow.
Planting	1.5	.90			.90	
Cost of seeds					.75	
Cost of shelling					.20	
1st cultivation	2	1.20	2	1.20	2.40	Wooden plow.
2nd cultivation	2	1.20	2	1.20	2.40	Do.
3rd cultivation	2	1.20	2	1.20	2.40	Do.
Harvesting	2	1.20			1.20	
Hauling	1	.60	1	.60	1.20	Bull-cart.
Cost of sacks					2.50	
Total	38	22.80	34.5	21.60	46.95	

REFERENCES

1. Annual Reports of the Insular Collector of Customs. 1931–1937.
2. Philippine Statistical Review 5 (1938) Nos. 1–2.
3. VIBAR, TORIBIO. Corn in the Philippines. B. P. I. unnumbered circular (1932) 1–27.

ILLUSTRATIONS

PLATE 1

A field of corn.

PLATE 2

FIG. 1. Calamba yellow flint corn.
2. Rice pop corn.

PLATE 3

Cebu white flint corn.

PLATE 1.

1

2

PLATE 2.

PLATE 3.

RICE LEAFHOPPERS

1. *Nephotettix apicalis* Motch.
2. *Nephotettix bipunctatus* Fabr.

Local names: Hanip (Tagalog), sip-sip (Ilocano), po-or or po-ol (Pangasinan)

(Farmers' Circular No. 49)

By Roman Abalos

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TWO PLATES

Among the most serious pests of rice in the Philippines are two species of leafhoppers, known in science as *Nephotettix apicalis* Motch., and *Nephotettix bipunctatus* Fabr., both of the family Cicadellidae. These insects attack rice plants in all stages of growth and often cause considerable damage. The insects are usually abundant during the months of August, September, and October.

Since the insects destroy the rice plants by inserting their beaks into the leaves and the leaf sheaths and then suck the juice, they are called "sip-sip by the Ilocano farmers. These two species of leafhoppers prefer to stay on the leaf sheaths and on the leaves of the plants. The early sign of injury is the drying of the tip of the older leaves and the presence of yellow spots on the midribs and the leaf sheaths. The plants are stunted. In cases of serious infestations the plants appear as if burned, for which reason the farmers of Pangasinan call the trouble "po-ol" or "po-or." In the absence of rice plants, the insects feed on wild grasses growing in or near the rice field.

DESCRIPTIONS

Nephotettix apicalis Motch., is pale green in color with a length of from 5 to 5.5 mm. from the tip of the head to the tips of the wings. The head has a transverse black line connecting the two compound eyes. One third of its outer wing from the tip (apical third) is dark. The male has a black elongated dot on the middle of each outer wing, which is absent on the female. The full grown nymph is creamy with irregular markings on the body.

Nephotettix bipunctatus Fabr., closely resembles *Nephotettix apicalis* Motch., but the former is smaller, measuring from 4.5 to 5 mm. and has no transverse black line connecting the two compound eyes. The male has a black circular spot before the middle of each outer wing. The full grown nymphs are pale green.

LIFE HISTORY

The adults of these two species lay their eggs in rows inserted into the leaf sheaths of the tender plants just below the epi dermis. The eggs are about a millimeter long, whitish in color and can not be seen without the aid of a hand lens. The newly hatched nymphs undergo five molts before they become adults with fully developed wings. The life cycles of these two species are as follows:

	Days
Nephotettix apicalis Motch.	
Egg stage	7 to 9
Nymphal stage	14 to 19
Nephotettix bipunctatus Fabr.	
Egg stage	5 to 10
Nymphal stage	13 to 18

These two species of leafhoppers begin to lay their eggs 2 or 3 days after they emerge as adults.

CONTROL MEASURES

Since these two species have similar life histories and habits, the following control measures are suggested:

1. *Sweeping with net.*—A cone-shaped bag made of cheese cloth attached to a stiff circular wire and mounted on a short stiff wooden handle will serve the purpose. The net must be swung back and forth striking the leaves of the plants. The insects caught at the bottom of the net can then be killed by crushing them.

2. *The use of hopperdozer.*—An empty petroleum can should be cut longitudinally into halves along opposite corners. The inside surface of one of the halves should be smeared with tangle foot and a convenient handle nailed along one of its sides as shown in Plate 2, fig. 3. This is used in the same manner as a hand net, that is, it is swung back and forth touching gently the rice plants as the operator moves along. The disturbed leafhoppers will fly or jump and are caught by the tangle foot in the hopperdozer.

3. *Application of kerosene.*—If the field is still under water and the plants have but few leaves, application of kerosene helps much to control the pests. Kerosene should be applied to the paddy so that a thin film is formed on the surface of the water. By gently striking the plants with stick, rope or similar materials, the insects fall on the water and come in contact with the kerosene, which soon kills them by suffocation. Care should be taken, however, that kerosene is not excessively applied as to burn the plants. The water with the kerosene film should be drained off and replaced with fresh water after the insects have been killed.

4. *Light trapping.*—A lantern set on a basin of water coated with a thin film of kerosene may be used. Being attracted to light, the adult hoppers fly to the lantern, fall to the basin and thus get drowned. The moving light trap is recommended for this purpose. Two persons shall work side by side in the field at night, one carrying a lantern on a basin of water coated with kerosene, the other gently striking the rice plants with stick, rope or other similar materials. The disturbed leafhoppers will then fly to the light and fall to the basin where they get killed. This method of control by light trap should be employed early in the season in order to catch the adults before they lay eggs on the rice plants. According to the experiment conducted by the writer, this method of moving light trap can catch even twenty times more than the stationary light trap.

5. *Spraying with contact poison.*—Soap solution spray with a concentration of 8 grams of soft, yellow laundry soap per liter of water may be used. A pump with a good nozzle that will deliver a spray in a fine mist should be used. The plants should be sprayed thoroughly so as to moisten the insects. Spraying should be done once a week until the pest is well under control.

6. *Application of fertilizer.*—If the soil is poor fertilization should be practiced as this will make the plants more vigorous, thus rendering them more resistant to pests. A compound fertilizer containing from 10 to 20 per cent each of nitrogen and phosphoric acid may be applied at the rate of 100 to 150 kilos per hectare. Before applying, the surplus water in the field, if any, should be drained off to about an inch deep.

7. *Clean culture.*—In view of the fact that the pests subsist on wild grasses during the off season for rice, clean culture should be widely practiced by the farmers. Grasses on which

the pests may feed and breed should be burned or destroyed to at least minimize their number. During the planting season, the field should be thoroughly prepared and rid of weeds.

8. *Selection of variety.*—Good yielding varieties of rice plants growing in the locality may be found to be more resistant to the attack of the pests, if they are naturally rank growers.

9. *Encouragement of their natural enemies.*—Birds such as the common swallow, shrike, and golden-headed cisticola, and dragon flies, spiders, frogs and young mud fish feed on the nymphs and adults insects. As far as practicable, these natural enemies should be protected and their multiplication encouraged.

ILLUSTRATIONS

Plate 1

Development of *Nephotettix apicalis* Motch.

Fig. 1. Portion of the stem of rice plant with eggs inserted just below the epidermis of the leaf sheath. (×3)
2. Egg. (×20)
3. First instar. (×20)
4. Second instar. (×20)
5. Third instar. (×20)
6. Fourth instar. (×20)
7. Fifth instar. (×20)
8. Adult female. (About ×20)
9. Adult male. (About ×20)

Plate 2

Nephotettix bipunctatus Fabr.

Fig. 1. Adult female. (About ×20)
2. Adult male. (About ×20)
3. Diagrammatic drawing of hopperdozer.

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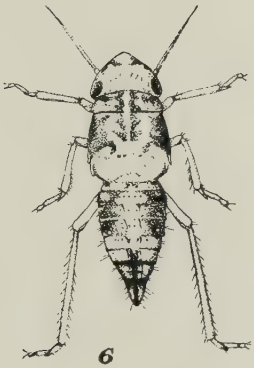
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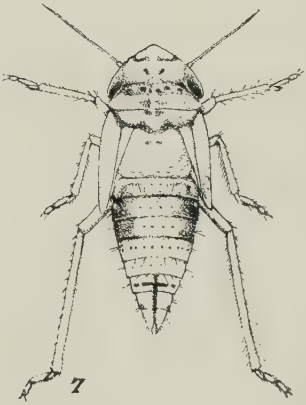
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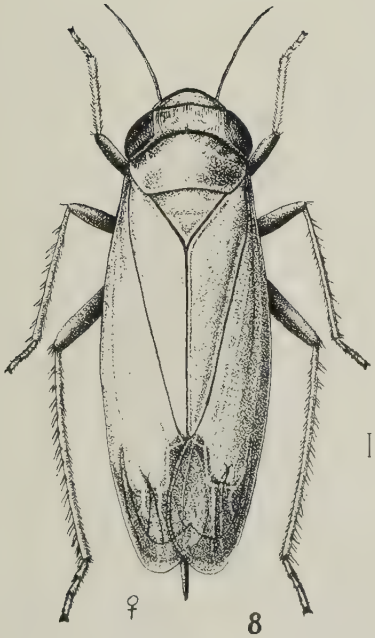
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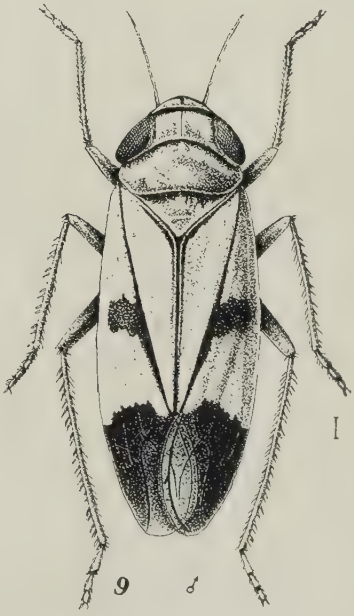
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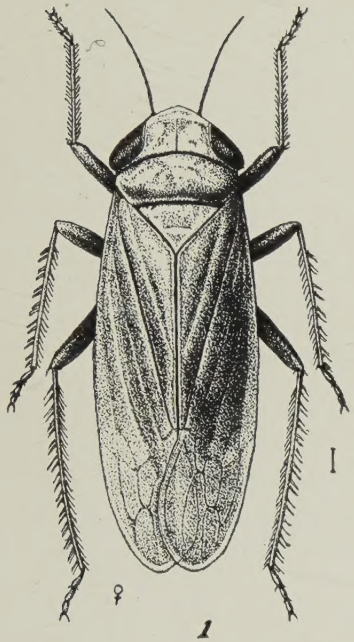
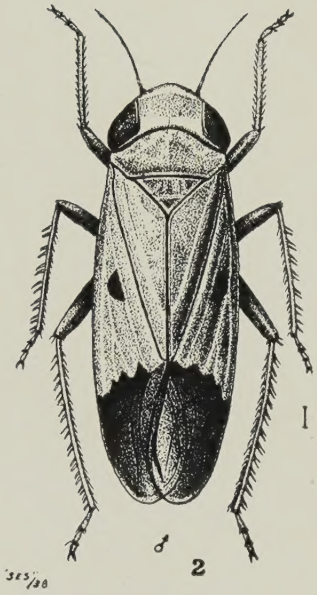
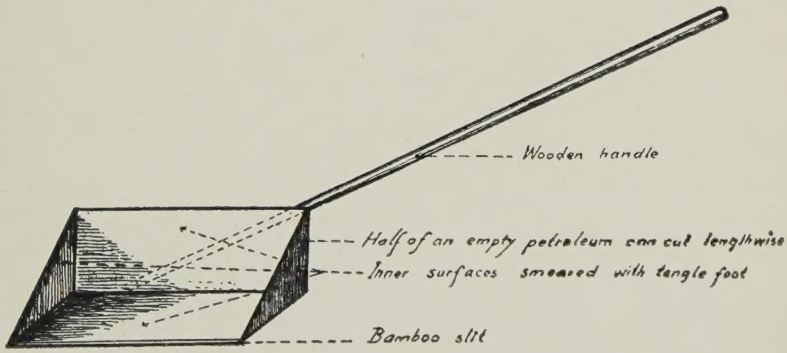
PLATE 1.







Diagramatic drawing of hopperdozer

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PLATE 2.

BUREAU OF PLANT INDUSTRY

AGRICULTURAL STATIONS AND SEED FARMS

1. Central Experiment Station, Manila
2. Lamao Horticultural Station, Limay, Bataan
3. Lipa Coffee-Citrus Station, Lipa, Batangas
4. Gandara Seed Farm, Gandara, Samar
5. Baguio Plant Industry Experiment Station, Baguio
6. Maligaya Rice Station, Muñoz, Nueva Ecija
7. Ilagan Tobacco Station, Ilagan, Isabela
8. Maridagao Rubber Station, Pikit, Cotabato
9. Los Baños Economic Garden, Los Baños, Laguna
10. Sta. Maria Plant Propagation Station, Sta. Maria, Ilocos Sur

SUB-STATIONS

1. Davao Seed Farm, Davao Penal Colony, Davao
2. Halcon Rubber Sub-Station, Baco, Mindoro
3. Gingoog Lanzon Reservation, Gingoog, Oriental Misamis
4. Kidapawan Tobacco Sub-Station, Cotabato
5. Tanauan Citrus Sub-Station, Tanauan, Batangas

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